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EAST AFRICA HIGH COMMISSION

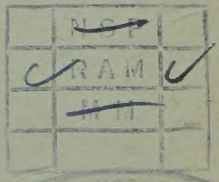
EAST AFRICAN AGRICULTURE
AND
FORESTRY RESEARCH ORGANIZATION

RECORD OF RESEARCH

for the period

1st January to 31st December, 1959

ANNUAL REPORT, 1959



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EAST AFRICAN AGRICULTURE
AND
FORESTRY RESEARCH ORGANIZATION
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DIRECTORATE

E. W. Russell, M.A., PH.D., F.INST.P.	*Director*
H. C. Pereira, B.SC., PH.D.	*Deputy Director*

RESEARCH DIVISIONS

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H. G. Livingston, B.SC., PH.D., DIP. DAIRY HUSBANDRY	*Animal Nutritionist*
H. P. Ledger, N.D.D.	*Farm Manager*
A. F. Dent, DIP. AGRIC., DIP. DAIRYING	*Assistant Farm Manager*
K. R. Southon, DIP. AGRIC. (EGERTON)	*Agricultural Assistant*
Mrs. A. E. Bazin	*Scientific Assistant*
Watson Njenga	*Laboratory Assistant*
Nelson Mwangi	*Recorder*
James G. Rimomo	*Recorder*
Mayda Kapitapa	*Farm Overseer*

CHEMISTRY:

H. F. Birch, B.SC., PH.D.	*Chemist-in-Charge*
Mrs. C. C. Hood, B.SC.	*Scientific Assistant*
Paul Mungai	*Laboratory Assistant*

GENERAL CHEMICAL ANALYSIS:

M. T. Friend, M.SC., A.R.I.C.	*General Chemical Analyst*
Leonard Nganga	*Laboratory Assistant*

SPECTROCHEMISTRY:

G. T. Chamberlain	*Spectrochemist*
A. J. Searle	*Scientific Assistant*
C. A. Spinage	*Scientific Assistant*

ECOLOGY:

C. G. Trapnell, O.B.E., B.A.	*Ecologist*

FORESTRY:

A. L. Griffith, O.B.E., M.A., D.SC.	*Silviculturist-in-Charge*
P. Howland	*Scientific Assistant*
Evanson Ndungu	*Laboratory Assistant*
Amos Wanene	*Laboratory Assistant*
Ernest Warari Muregi	*Overseer*

FOREST ENTOMOLOGY:

T. Jones, B.SC., A.R.C.S.	*Forest Entomologist*
W. Wilkinson, B.SC., M.I.BIOL.	*Forest Entomologist*
Josephat Kamau	*Laboratory Assistant*

HORTICULTURE AND NURSERY:

W. B. May, F.R.H.S.	*Horticulturist*
Ndungu Ngware	*Laboratory Assistant*
Angel Gathara	*Overseer*

MICROBIOLOGY:

Mrs. M. A. Ledger, N.D.D.	*Scientific Assistant*
Chege Mugane	*Laboratory Assistant*

NEMATOLOGY:

A. G. Whitehead, B.SC., A.R.C.S.	*Nematologist*
Miss E. M. Boehm, B.SC.	*Scientific Assistant*

PHYSICS:

(H. C. Pereira, B.SC., PH.D.)	*Physicist-in-Charge*
O. Kerfoot, B.A., B.SC.	*Silviculturist*
J. S. G. McCulloch, B.SC., PH.D., A.INST.P.	*Agricultural Meteorologist*
M. Dagg, B.SC., PH.D.	*Soil Physicist*
P. H. Hosegood	*Scientific Assistant*
J. W. Simmons	*Scientific Assistant*
Ezekiel Kasavuli	*Senior Observer*
Augustino Waratho Charles	*Laboratory Assistant*
Peter Ngugi Nganga	*Laboratory Assistant*
Jacob Mudianga	*Laboratory Assistant*
Wallace Gichuru	*Laboratory Assistant*
Eliud Ndungu Kago	*Laboratory Assistant*
Francis Ngugi Charles	*Laboratory Assistant*
Joshua Njoroge Kuria	*Laboratory Assistant*

PLANT BREEDING AND GENETICS:

H. Doggett, M.A., A.I.C.T.A.	*Plant Breeder-in-Charge*
D. Jowett, B.SC., PH.D.	*Plant Breeder*
T. Graham	*Agricultural Assistant*
Henry Ojulong	*Laboratory Assistant*
Barnabas Kifua	*Laboratory Assistant*
Augustine Acuri	*Laboratory Assistant*
John Oposia	*Laboratory Assistant*

PLANT PATHOLOGY:

H. H. Storey, C.M.G., M.A., PH.D., F.R.S.	*Plant Pathologist*
Miss F. M. L. Sheffield, D.SC.	*Plant Pathologist*
Mrs. A. K. Howland, B.SC.	*Scientific Assistant*
Ferdinand Wamagata	*Laboratory Assistant*
Geoffrey Kuria	*Laboratory Assistant*
James Kuria Njoroge	*Laboratory Assistant*

PLANT PHYSIOLOGY:

J. Glover, M.SC.	*Plant Physiologist*
Henry Thuku Rimi	*Laboratory Assistant*
Edward Stephen Waweru	*Laboratory Assistant*

SOIL SURVEY:

R. M. Scott, B.SC.	*Soil Surveyor*

SYSTEMATIC BOTANY:

B. Verdcourt, B.SC., PH.D.	*Botanist-in-Charge of the E.A. Herbarium*
Miss D. M. Napper, B.SC.	*Scientific Assistant*
R. M. Polhill, B.A.	*Scientific Assistant*
George Williams	*Laboratory Assistant*
Edward P. K. Kaya	*Laboratory Assistant*
Petro C. Owite	*Clerk*

MISCELLANEOUS SCIENTIFIC SERVICES

JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY:

Mrs. L. D. Verdcourt, A.L.A.	*Librarian*
Mrs. F. M. Searle	*Assistant Librarian*
Daniel Lazarus	*Assistant Librarian*
Joseph Okakah	*Bookbinder*

THE EAST AFRICAN AGRICULTURAL JOURNAL:

(J. Glover, M.SC.)	*Editor*
Mrs. P. D. Hosegood	*Assistant Editor*
Mrs. P. A. Chamberlain	*Assistant Editor*

THE EAST AFRICAN PLANT QUARANTINE STATION:

(Miss F. M. L. Sheffield, D.SC.)	*Pathologist-in-Charge*
P. J. Dickinson, DIP.HORT.	*Scientific Assistant*
Peter Mwithiga	*Overseer*

ADMINISTRATION

ADMINISTRATION AND ACCOUNTS:

Lt.-Col. G. G. Robson, p.s.c.	*Administrative Secretary*
(H. B. Hobkirk)	*Accountant, posted from Accountant General's Department*
Miss M. A. E. Vardy	*Personal Secretary to Director*
Mrs. M. M. May	*Personal Secretary*
Mrs. V. C. T. Knight, M.A.	*Personal Secretary*
Mrs. G. L. Dickinson	*Personal Secretary*
Mrs. W. Griffith	*Secretary/Stenographer*
(B. B. Purohit)	*Accounts Clerk, posted from Accountant General's Department*
(S. I. Mascarenhas)	*Accounts Clerk, posted from Accountant General's Department*
Matthew N. Waweru	*Administrative Clerk*
Edward Munyua	*Clerk*

MAINTENANCE, WORKSHOPS AND STORES:

J. B. Drummond, M.I.C.W.A.	*Senior Maintenance Superintendent*
R. N. Angus	*Assistant Maintenance Superintendent*
L. R. F. D'Souza	*Storekeeper*
Sher Mohamed	*Foreman Artisan*
Vir Singh	*Foreman Artisan*
Noor Mohamed	*Foreman Artisan*
Soma Puna	*Senior Artisan*
Arthur Robert	*Artisan*
Ngaruiya Waweru	*Artisan*
Kamau Kangethi	*Artisan*
Muigai Njuguna	*Artisan*
Peter Kimani Mukuria	*Artisan*
Kamiti Gichuhi	*Artisan*
Mohamed Hassan	*Artisan*
Mwaura Ngabu	*Artisan*
Benson Gaitho	*Artisan*
Benson Mukumi	*Artisan*
John Kihanya	*Artisan*
Kiarie Gachohi	*Artisan*
Kiarie Ndongo	*Artisan*
Kiragu Ndungu	*Artisan*
Njuguna Kibe	*Artisan*
Geoffrey Mburu	*Stores Clerk*
John Ndungu	*Clerk*
Saduma Otiende	*Clerk*
Joseph N. Njoroge	*Clerk*
William K. Peter	*Clerk*
Jackton Owake	*Overseer*
Kitonga Kiarie	*Driver*
Kinyanjui Macharia	*Driver*
Muchane Wamuti	*Driver*

DEPARTURES DURING 1959

L. R. Doughty, B.SC. (AGRIC.), N.D.A.	*Geneticist, on leave pending retirement*
D. W. Duthie, M.A., B.SC., PH.D., F.R.I.C.	*Biochemist, on retirement*
J. W. Millbank, B.SC., PH.D.	*Microbiologist, on resignation*
J. G. B. Newbould, B.A.	*Scientific Assistant, E.A. Herbarium, on completion of contract*

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PREFACE

The East African Agriculture and Forestry Research Organization (E.A.A.F.R.O.) is an interterritorial research organization administered by and forming part of the East Africa High Commission. It was set up in 1948 and absorbed the earlier East African Agricultural Research Institute at Amani, Tanganyika, which was started in 1927. E.A.A.F.R.O. is financed jointly by the three East African Territories of Kenya, Tanganyika and Uganda, by the Protectorate of Zanzibar, and by the United Kingdom Government through Colonial Development and Welfare Funds. Its headquarters and central laboratories, experimental farm and forest plantations are in Muguga Forest near Nairobi on a site generously given by the Government of Kenya.

E.A.A.F.R.O. works very closely with the corresponding organization for veterinary research, the East African Veterinary Research Organization (E.A.V.R.O.). The two organizations have a common headquarters at Muguga, and the two sets of laboratories and farms are on adjoining estates each excised from the Muguga Forest. They are jointly responsible for the Library, which is the largest and most complete library for agriculture and the agricultural and ancillary sciences in East Africa. In addition, research work on animal industry is shared out between them. It was originally carried out by the Joint Animal Industry Division under Dr. M. H. French, a Deputy Director, and it was a joint responsibility of the two Directors. With Dr. French's retirement in 1956 it was agreed that this joint Division be divided into two: an Animal Husbandry Division under the Director, E.A.A.F.R.O. and an Animal Production Division under the Director, E.A.V.R.O. Muguga South Farm, which was used by the Joint Division, is still being used by the two Divisions, though it is now managed by the Director, E.A.A.F.R.O.

The general research policy for E.A.A.F.R.O. is decided by the East African Agricultural and Fisheries Research Council, a Council whose members are nominated by the Territorial Governments, the High Commission and the Colonial Office, and this Council is also responsible for the general running of this Organization.

The principal functions of E.A.A.F.R.O. are to undertake research work that is either longer-termed than is easily undertaken by the Territorial Departments of Agriculture and Forestry, or is common to all or several of the Territories, or which requires highly specialized equipment or research officers, which can only

be justified in a central East African laboratory. Examples of each of these types of work will be found in the body of this Report. E.A.A.F.R.O., however, is only concerned with problems of local interest when specially invited by a Territorial Department. Its function is therefore to supplement and supply the background to the work of the territorial research workers.

The planning of the detailed research policy of E.A.A.F.R.O. must obviously be done in very close co-operation with the Territorial Departments, and this is ensured through three Research Co-ordinating Committees. These Committees, and others for other sciences, are under the Chairmanship of the Chief Administrative Secretary of the High Commission, and the Director E.A.A.F.R.O. is a member of each. These Committees are for Agriculture, on which are the four Territorial Directors of Agriculture; for Animal Industry, on which are the Directors of Agriculture, the Directors of Veterinary Services and the Director E.A.V.R.O.; and for Forestry on which are the Chief Conservators of Forests. These Committees, in conjunction with the Research Council, keep under review all the research work in progress and decide on general priorities for research, particularly the longer-term or more specialized research that is the direct concern of E.A.A.F.R.O.

E.A.A.F.R.O. is also directly concerned with a further set of Committees, the Specialist Committees, which are composed of the actual specialist research workers in East Africa in each of the disciplines represented. These Committees are therefore competent to discuss the technical problems with which the research workers are faced in carrying out their work, and to make detailed proposals for new work or for an extension of current work.

It was decided at the 3rd Meeting of the Research Council held on 3rd February, 1955, that the Annual Reports of E.A.A.F.R.O. should be published in two parts; one part, which is contained in the Annual Report of the Research Council itself, is intended to tell the non-scientist of the work and achievements of E.A.A.F.R.O. in the year under review; the other part, which is this Report, is written more for the information of research workers, particularly in other parts of the world.

INTRODUCTION

CHANGES IN STAFF AND ORGANIZATION

1. *Staff Changes.* Three new Research Officers joined the staff during the year. Mr. T. Jones, who was in charge of the West African Timber Borer Research Unit, joined the Forest Entomology Division, Dr. H. G. Livingston joined the Animal Husbandry Division, and Dr. D. Jowett the Sorghum Breeding Research Unit at Serere. In addition, Mr. G. L. Lucas has been appointed as a Botanist to the Herbarium, but is at present undergoing a year's training in Kew.

2. Two Research Officers left during the year. Dr. J. W. Millbank, Microbiologist, resigned after the end of his tour to take up a post in Great Britain, and Dr. D. W. Duthie, the Biochemist, retired after 15 years' service. He joined the staff of the old East African Agricultural Research Institute at Amani in 1944, and besides having worked either in the chemistry or biochemisty fields has also been Editor of the *East African Agricultural Journal* for most of this period.

3. *Reorganization of Divisions.* The year 1959 has seen a reduction in the scope of problems on which this Organization will work, consequent upon the decision of the East African Agricultural and Fisheries Research Council to reduce the establishment of Research Officers from 28 to 23. This has been necessary because of the financial stringency in the East African Territories, and a reduction in the scale of the grants from the Colonial Development and Welfare funds for the next five years. In consequence, it has been agreed to reduce very considerably the work dealing with soil fertility, because the Departments of Agriculture all have a number of Soil Chemists on their establishment. But the decision also means that for the next few years several Divisions will have only one Research Officer, and our experience is showing that on the whole it is much more difficult for these Divisions than for the larger ones to play their full role in co-operative interterritorial research.

4. A reduction also has had to be made in the number of Scientific Assistants from 20 to 14, and this reduction has already begun to limit the amount of co-operative work this Organization can undertake with the Territorial Departments. It is particularly unfortunate it has had to come at the present time, just as so many co-operative projects are getting under way. However, every

opportunity will be taken to reorganize the staffing of the Divisions to minimize the effects of these reductions in establishment in those fields of work in which the Territories are most anxious for our co-operation. It will have the consequence, however, that it may become increasingly difficult for our staff to carry out even essential scientific research if it does not have a fairly immediate bearing on urgent practical problems.

5. *Grants from Outside Organizations.* It is very gratifying to report that we have received some very generous help from the Rockefeller Foundation. They gave Mr. H. Doggett, who is in charge of our Sorghum Breeding Research Unit, a fellowship to visit the principal sorghum breeding laboratories in the United States, where spectacular improvements in the sorghums have recently been made, and in Mexico where the agricultural conditions are fairly similar to our own in East Africa. The Foundation has also made a grant of up to £3,000 for eight new glass-houses and a potting-shed mainly for the use of the Nematology Division. This is a new Division but no moneys could be made available from East African sources for these essential requirements. When these glass-houses are erected it is hoped that Mr. A. G. Whitehead, the Nematologist, will develop his work on methods for controlling the damage plant parasitic nematodes are doing the various crops in East Africa much more rapidly than would have otherwise been possible.

6. The Nuffield Foundation has also expressed their willingness to finance two additional lines of work at E.A.A.F.R.O., closely related to work already in hand, namely further research on the physiology of drought resistance in crops, and on the possibilities of raising the nitrogen status of tropical soils by suitable use of indigenous tropical legumes. These two lines of work would be carried out by overseas research officers working here for periods of about one to two years, and our next task is to find and attract suitable scientists who would like to avail themselves of these grants.

7. *Visiting Scientists.* Two visiting research workers have each spent several weeks at E.A.A.F.R.O. working in the Plant Physiology and Physics Divisions. The first was Dr. H. Barrs, a Plant Physiologist on his way from the United Kingdom to take up an appointment at the Katherine Research Station in Australia. The second was Dr. I. Dirmhirn from the Central Meteorological Institute, Vienna, who was working with our Research Officers on the measurement of solar radiation. Finally, at the end of the year, Mr. J. Goode, a Principal Scientific Officer from the East Malling

Research Station in England, started a two-month visit. It is a great pleasure to thank the Colonial Office, the Agricultural Research Council and the Director of the East Malling Research Station, for making possible this visit. It is hoped that E.A.A.F.R.O. can maintain a sufficiently high scientific reputation to attract Research Officers from the United Kingdom Research Stations to work here with members of our staff on problems of mutual interest and importance in the two countries.

WORK ON OUTSIDE COMMITTEES

8. The Director is a member of the E.A. Agricultural, Animal Industry and Forestry Research Co-ordinating Committees, and Chairman of the Soil Fertility and Pasture Research Specialist Committees. He is a member of the Kenya Agricultural and Veterinary Research Advisory Committee, the Kenya Pasture Research Committee, the Chairman of the Research Committee of the Tanganyika Coffee Growers' Association, a member of the Research Committee of the Tanganyika Sisal Growers' Association, a member of the Governing Body of the Tea Research Institute of East Africa and Chairman of its Research Committee, and a member of the Namulonge Advisory Board of the Empire Cotton Growing Corporation. He is a member of the Scientific Council for Africa South of the Sahara (C.S.A.) and attended the 10th Meeting in Kampala, and he was Chairman of the C.S.A. Meeting of Specialists in Hydrology held in Yaoundé. He is also a member of the Agricultural Research Council recently set up in the Federation of Rhodesia and Nyasaland. In co-operation with the Provincial Agricultural Officer, Rift Valley Province, he helped to organize and was Chairman of a Working Party on methods of research for improving African grazing lands, held in Baringo, and in co-operation with the Chief Research Officer, Uganda Department of Agriculture, helped to organize and was Chairman of a conference on the classification of East African soils held at Kawanda.

9. Dr. H. H. Storey is a member of the E.A. Medical Research Council and the E.A. Industrial Research Board, and a Trustee of the Coryndon Museum. He is Chairman of the Specialist Committee for Agricultural Botany, and Chairman of the E.A. Standing Technical Committee on Plant Import and Export, of which Dr. F. M. L. Sheffield is also a member and Mr. P. J. Dickinson of the E.A. Plant Quarantine Station is the Secretary.

10. Dr. Pereira is the Secretary of the E.A. Catchment Area Research Committee, the Kenya Catchment Area Research Committee and the E.A. Regional Committee for the Conservation and Utilization of Soils, which held its third Meeting at Usumbura in July, which both he and Dr. Dagg attended. He also attended the C.S.A. Meeting of Specialists in Hydrology. Dr. A. L. Griffith is a member of the E.A. Timber Advisory Board and Chairman of the Specialist Committee on Forestry. He also attended the C.S.A. Meeting on Open Forests in Ndola. Dr. W. J. A. Payne is a member of the Kenya Pasture Research Advisory Committee and the Kenya Pig Industry Board's Show, Research, Food and Field Advisory Committee, as is Dr. H. G. Livingston.

WATER AND CROP GROWTH

THE WATER USE OF TREES AND CROPS AND ITS ESTIMATION FROM CLIMATIC DATA: THE EFFECTS OF LAND-USE CHANGES ON CATCHMENT AREA HYDROLOGY: THE EFFECTS OF TILLAGE PRACTICES ON RAINFALL INFILTRATION INTO SOIL

CATCHMENT AREA RESEARCH

H. C. Pereira, J. S. G. McCulloch, O. Kerfoot, M. Dagg, P. H. Hosegood, J. W. Simmons, assisted by Ezekiel Kasavuli, Augustino Charles, Peter Ngugi, Joshua Kuria, Daniel Levi, Sabino Obol, Jacob Mudianga, Eliud Kago, Francis Ngugi, David Njuguna, Samuel Kinyali and Eliud Ndungu

11. This has been the first priority task for the whole team. Useful progress has been made, in co-operation with officers of the many Territorial Departments involved, in all four of the main experiments in land-use hydrology.

12. In Uganda the basic study of the improvement of the severe flash-flooding behaviour of overgrazed Karamoja thornscrub country has given important but rather alarming observations. Livestock trampling has so effectively reduced rainfall infiltration that depth of penetration has been only of the order of one foot, in spite of annual rainfall totals exceeding 25 inches. Thus the degradation of vegetation due to induced drought is added to the effects of soil erosion and severe overgrazing.

13. An extensive, detailed and quantitative study of the vegetation by Mr. Kerfoot has provided data on the volume of fuel and building timber, and numerical composition of the scanty surviving herbage. While carrying out a detailed topographical survey, Mr. Simmons joined Mr. Wagg of the Uganda Water Development Department in the calibration (by current meters on heavy steel frameworks) of the torrent spates through the massive standing-wave flumes. The effects of the very heavy deposition of sand and gravel bedload have now been measured and allowed for, since they cannot be prevented. Quantitative water measurements are now being obtained.

14. Excellent progress has been made on the study of the conversion of tall rain forest to tea gardens. A substantial contribution from the Kenya Ministry of Agriculture, Animal Husbandry and Water Resources in the provision of funds and technical knowledge made it possible for Messrs. Brooke Bond (E.A.) Ltd. to build, to the designs of the Chief Soil Conservation Engineer, masonry flumes through which surface runoff from critical areas is recorded autographically. The careful planning and experienced direction of the Tea Company staff have ensured the remarkably rapid execution of an ambitious programme of forest clearing, road building, terracing and land preparation, while valuable assistance has been given to the research staff. Soil moisture sampling and energy-balance calculations have combined to give detailed and satisfactory accounts of the hydrological balance of both the valley under development and the adjacent forest control valley; the co-operation of the African Highlands Produce Company in providing water yield information on a nearby forested catchment of some 30 square miles, has provided very useful confirmation of the results obtained in the 3,000 acres area of the two test valleys.

15. In this experiment also, Mr. Simmons has completed the topographical survey under heavy forest cover, while Mr. Kerfoot has made a qualitative description of the vegetation, and his collection of botanical specimens has been identified by the E.A. Herbarium.

16. In the Aberdare Mountains the study of the large-scale change of land usage from bamboo forest to softwood plantations, in the main catchment area of Nairobi City's water supplies, has now yielded two full "water years" of good and consistent data. One important result, already well demonstrated, is that the energy-balance approach developed by Penman at Rothamsted, applies well in this high cool tropical forest area, particularly when the main component, the incoming solar radiation, is measured directly with the "Gunn-Bellani" integrator, a simple field distillation instrument whose use for this work has been developed by this Division.

17. A second result is becoming clear as this year's data from the high altitude catchments is compared with that from the comparison of water use of bamboo and softwoods which has been conducted jointly with the Kenya Forest Department since 1950. (E.A.A.F.R.O. Annual Report 1953, p. 53, gives some interim results.) In the high wet zones of the mountain forests the well-distributed annual rainfall is approximately twice the annual

evaporation. Under this local climate no large soil moisture deficits are built up, and the water use of the continuous canopies of trees and of bamboo appears to be independent of their size and root-range. At the lower extreme, annual evaporation not only equals or exceeds annual rainfall, but the distribution of the latter into wet and dry seasons is strongly marked. Here very large soil moisture deficits, amounting to as much as 14 inches, have been measured under the larger and older trees, whose root development exceeds that of the bamboo. These water deficits must be made good from subsequent rainfall before percolating rainfall can contribute to streamflow.

18. It is clear that the length of the rotation in softwood plantations should be related to the combined effect of climate and root range. More evidence will be collected in the coming year on this very important aspect of catchment area management.

19. Qualitative vegetation survey and description was completed by Mr. Kerfoot on the four valleys which are under intensive study. Botanical collections were identified by the E.A. Herbarium and the species list was issued as part of the Progress Report. All members of the Physics Division carried out field work on these Aberdare experiments during the year.

20. In Tanganyika, the Mbeya Range catchment studies have already shown that the steep hillside cultivation characteristic of much of the Southern Highlands Province causes losses of soil far greater than is apparent by inspection. The runoff reached a maximum rate of 76 cusecs per square mile from the cultivated catchment, with a minimum dry-weather flow of 0.9. The peak rate of runoff from the forested catchment was only 12 cusecs per square mile in spite of its very steep gradient (1 in 2.2 overall), but the minimum dry weather flow was very low at 0.03 cusecs per square mile.

20A. Even the fairly clear dry weather streamflow is carrying 12 times as much mineral soil from the cultivated valley as from the forested valley, while the heavy soil wash from the former valley during storms has repeatedly filled the large concrete silt-traps. The debate at the Hydrological Conference of East and Central African Engineers at Kampala in 1958 showed clearly that no sampling device capable of automatically collecting sediment-load samples from flood-peak levels has yet been designed. Dr. Pereira suggested, and the E.A.A.F.R.O. workshops constructed a pilot model of a suitable device, which was set up by the Divisional Engineer of Tanganyika's Water Development and

Irrigation Department late in 1959. A visiting team from Muguga will carry out detailed calibration work on this equipment during February, 1960, provided that the rains co-operate.

21. Progress Reports on the last three of the above experiments were compiled at Muguga as in previous years from contributions from all of the officers taking part and were discussed by field meetings of the departmental officers mostly concerned. Quantitative calibration of the flumes on the Uganda experiment was achieved only at the end of the year under review and a report on the data will be issued early in the New Year. An account of the tea plantation experiment was published in *Corona* and republished in the new *Tea Board of Kenya Journal*. A description of the methods of research employed in these experiments, with illustrative data, was published in *Nature* in December, 1959.

SOIL PHYSICS

M. Dagg, P. H. Hosegood and S. M. Kinyali

Pressure Membrane Equipment

22. Many soils have been passed through the pressure membrane equipment which is now in routine use for the determination of soil moisture contents at a tension of 15 atmospheres. Moisture contents at this tension have been found, in America, to agree fairly well with the soil moisture contents observed under wilting plants in the field and under wilting sunflower seedlings in the laboratory. A comparison between these three figures is being made for several important East African soils. Deep stone-free soils and severe dry seasons give many opportunities here to check wilting points in the field. Some results for Kikuyu Red Loam at Muguga are given in Table 1.

TABLE 1

COMPARISONS OF MOISTURE CONTENTS AT WILTING POINT AND AT 15 ATMOSPHERE TENSION IN KIKUYU RED LOAM

Depth	1 ft.	2 ft.	3 ft.	4 ft.	6 ft.	8 ft.	10 ft.
Moisture content at tension of 15 atmospheres ..	23·4	22·9	24·9	28·6	29·8	28·7	28·7
Moisture content in field under wilting wattle trees	20·4	22·7	24·5	28·0	27·8	29·0	30·2
Moisture content under wilting sunflower in laboratory	22·6	24·3	25·8	29·7	31·2	29·9	30·5

1. The first foot of soil in the field was sun-dried below wilting point.
2. Moisture contents are expressed as a percentage of dry weight of soil.

23. An alternative method of determining wilting points by exposing soil samples to an atmosphere with a relative humidity of 98.5 per cent has been tried but has not proved very satisfactory as yet. More development is required.

Irrigation

24. Preliminary work in an investigation into crop water use at the Mbarali Irrigation Scheme, Tanganyika, has been completed. Soil profiles of the most important soil types have been core-sampled and calibrated for water holding capacity between the one-third and the 15 atmosphere tensions. A rough check on water use by systematic soil moisture sampling is in progress and plots have been selected and delineated for a more detailed study.

25. Similar soil calibration work has been carried out on the farm of F. O'B. Wilson Ltd. at Ulu, Kenya, where lucerne is being grown on heavy black clay soils under sprinkler irrigation.

26. Soil moisture sampling to check calculations of irrigation needed for Kenya's arabica coffee plantations was continued at Ruiru, and a new set of irrigation control measurements was begun in the Rift Valley, in a new soil type and local climate.

27. Progress on this work, and on other irrigation work already begun or requested at other sites in Kenya and Uganda, has been held up by the severe restriction of E.A.A.F.R.O. funds which has prevented recruitment of our full staff establishment. At the end of the year retirement of an officer made it possible to begin recruitment of a field assistant, mentioned in the 1958 Annual Report, who will use a laboratory caravan at successive sites in order to take fully detailed measurements of crop requirements for irrigation water.

28. Analysis of Dines autographic rainfall records from the catchment area and irrigation experiments continued as described in the 1958 Annual Report, to build up descriptions of storm patterns and of the rainfall impact at the soil surface.

29. Core-samplings and laboratory measurements for volume-weight and soil moisture storage capacity were carried out on two of the catchment experiments.

AGRICULTURAL METEOROLOGY

30. Dr. McCulloch was absent on overseas vacation and study leave until September, and the work was carried on by the rest of the Division. A progress report on the study of the standard-

ization of evaporation pans, which was undertaken by Dr. Pereira at the request of the Hydrological Conference of British East and Central African Territories, was presented to a meeting of engineers at Lusaka. Calibration of radiation instruments was supervised by Dr. Dagg, while field studies of the shade pattern and yield of tea bushes were continued by Mr. Kerfoot. Albedo measurements, using a reversible mounting for a portable Kipp thermopile, maintained in the horizontal plane by a heavy pendulum were begun, ten pairs of readings per hour being taken from dawn to dusk over evaporation pans, grass lawns, bare soil and tea bushes.

TABLE 2

MEASUREMENTS OF ALBEDO NEAR THE EQUATOR

Type of Cover	Albedo (Mean Daily Values)	Remarks
Open Water	0·09	Over a sunken pan 120 cm. diam. and 30 cm. deep, black painted internally.
Bare Soil	0·08	Kikuyu Red Loam with a dry dusty tilth.
Short Grass	0·21	Closely mown green lawn in dry weather.
Bamboo Forest ..	0·12	Mature continuous canopy, 40 ft. high.
Tea Bushes	0·16	Above plucking table of mature bushes.
Broad-leaved trees ..	0·18	Above a canopy 40 ft. high.

31. Dr. McCulloch returned to duty in September having obtained the Post-Graduate Diploma in Statistics (Biometrics) at the University of Aberdeen. The last quarter of the year was devoted to field inspections and laboratory work on the processing of the substantial volume of climatological measurements which now flow continuously to Muguga from the experiments in the Territories.

32. At the Munitalp-W.M.O. Symposium on Tropical Meteorology, held in Nairobi in December, Dr. Pereira and Dr. McCulloch presented a summary of measurements of the flow of heat energy to the atmosphere from the surfaces of bare soils, pastures, crops and forest canopies.

33. As a result of field studies by Dr. Pereira, described in the 1958 Annual Report, the Forest Departments of Tanganyika and of Kenya agreed to undertake simple rainfall and streamflow

SUMMARY OF METEOROLOGICAL OBSERVATIONS AT MUGUGA, 1959

	RAINFALL	AIR TEMPERATURE			AIR HUMIDITY			WIND SPEED	RADIATION	SUNSHINE	OPEN WATER EVAPORATION			
		MONTHLY MEANS OF DAILY VALUES									MONTHLY TOTALS			
	Monthly Totals	Max.	Min.	Mean	Dew Point Mean of 0830–1600	Saturation Deficit Mean of 0830 and 1600 hrs.	R.H. at 1600 hrs.	Mean Wind Speed at 6 ft. above ground	Kipp-Moll Solarimeter	Mean Daily Sunshine Hours	Sunken Pan Air-Insulated from Soil	Australian Pattern 3 ft. Deep Sunken Tank	Raised Pan with Light Grid Cover	Class "A" Pan
	Inches	°F	°F	°F	°F	mm. of Mercury	%	M.P.H.	Inches* Water Evaporated	Hours	Inches	Inches	Inches	Inches
Jan.	0·65	73·4	53·4	63·4	52·1	4·88	49	9·9	11·42	8·9	7·20	6·84	7·83	8·56
Feb.	1·71	76·1	53·4	64·8	50·3	6·18	40	8·5	10·43	9·4	7·41	7·09	8·25	9·00
Mar.	2·46	74·4	54·2	64·3	51·8	5·36	46	8·0	11·05	8·8	7·40	7·15	7·75	9·12
April	4·05	70·5	54·5	62·5	54·9	3·39	60	8·4	9·25	7·6	5·96	5·60	5·38	6·96
May	6·23	69·3	53·3	61·3	56·2	2·27	67	5·5	8·23	6·3	4·57	4·26	4·06	5·43
June	0·06	67·1	48·7	57·9	50·9	2·74	59	5·4	8·27	7·4	4·47	4·36	4·72	5·39
July	0·52	65·9	47·3	55·3	49·2	2·26	56	5·3	6·92	5·1	3·86	3·67	4·33	4·73
Aug.	1·25	67·3	48·4	57·8	49·8	3·02	56	6·5	7·91	5·7	4·48	4·29	5·07	5·61
Sept.	0·82	71·2	48·4	59·7	49·5	4·05	48	6·8	9·18	7·2	5·45	5·17	6·17	6·74
Oct.	0·80	73·4	52·0	62·7	49·2	5·46	41	8·4	10·46	7·8	6·96	6·77	8·26	9·03
Nov.	9·83	69·7	53·4	61·6	54·6	3·07	65	8·6	8·57	6·9	5·82	5·57	6·27	6·68
Dec.	2·20	69·0	53·0	61·0	53·4	3·23	59	8·9	11·12	9·3	6·16	5·87	6·80	7·18
Annual Totals	30·58	—	—	—	—	—	—	—	112·81	—	69·74	66·64	74·89	84·43
Annual Means	—	70·6	51·7	61·0	51·8	3·82	54	7·5	—	7·5	—	—	—	—
Average Total	37·77 (9)†	—	—	—	—	—	—	—			64·43 (7)†	60·57 (5)†	70·55 (7)†	
Average Mean		69·8 (7)†	51·9 (7)†	60·8 (7)†	52·2 (7)†	3·63 (7)†	—	7·1 (7)†	—	7·3 (7)†	—	—	—	—

*1 inch water evaporated = 1,498·6 gm. cal/sq. cm. †No. of years in brackets.

observations in order to remedy the almost complete lack of data from some of their more remote protective forests on Catchment Areas. During 1959 Mr. Kerfoot visited three of these forests and erected Muguga-type storage raingauges, and also set up several staff gauges supplied by the Ministry of Works. He also took the opportunity of recording qualitative botanical descriptions of the vegetation.

TREE ROOT STUDIES

O. Kerfoot and Eliud Ndungu

34. In addition to the work in the catchment areas already described, Mr. Kerfoot selected, enumerated and took detailed measurements on sample plots of different ages laid out in *Pinus radiata* and *Pinus patula* plantations in the South Kinangop Forest Reserve. Soil moisture measurements from the profiles supporting trees of varying diameter and in different age-classes are a significant part of the general study on the relationship between length of rotation of the crop and the water regime in the area concerned.

35. With the kind co-operation of Messrs. Brooke Bond (E.A.) Ltd., Mr. Kerfoot excavated and washed out the root systems of mature *Grevillea* shade trees and adjacent tea bushes at Mabroukie Tea Estate, Limuru. Contrary to widespread beliefs, although the main tap-root of a maturing *Grevillea* shade tree extends to 20 feet or more, there is only sparse and heavily suberized lateral spread beyond 8 feet. The fine fibrous tea roots however, ramify throughout the soil profile to a depth of 14 feet and thoroughly exploit the whole of the soil volume. This bears out soil moisture sampling mentioned in the 1958 Annual Report which showed that closely spaced tea dried out the soil more thoroughly than did an association of tea and Grevillea shade. This detailed study of root distributions is basic to the understanding of water relationships of tea and shade and the problems of planting distances of tea bushes. Mr. Kerfoot will expand this to a range of climates and soils during 1960. Excellent root photographs have been obtained by Mr. C. Spinage who is the official photographer for the Organization.

SCIENTIFIC LIAISON

36. Dr. Pereira, as Secretary, and Dr. Dagg, as an observer, attended a conference and field meeting of the Eastern African Regional Committee for the Conservation and Utilization of Soils at which the Government of Ruanda Urundi acted as hosts to agriculturists and engineers from some eight neighbouring Territorities. The meeting studied the very successful peasant irrigation schemes developed by the Belgian authorities.

37. Three visiting workers spent periods of from one to two months with the Physiology and Physics Divisions of E.A.A.F.R.O., taking part in the experimental work in order to compare and discuss techniques for the study of water use by plants. They were Dr. Henry Barrs of the C.S.I.R.O., Australia; Mr. J. Goode of the East Malling Research Station in Kent, and Miss Inge Dirmhirn, Director of the Zentralanstalt fur Meteorologie und Geodynamik, Vienna.

PLANT PHYSIOLOGY

J. Glover

Drought

38. At the request of the Chief Research Officer, Tanganyika Territory, part of the work of this Section was devoted to a study of the reaction of groundnut stomata to drought. Local "bunch" varieties of economic importance to Tanganyika were investigated. It was found that so far as the vegetative phase was concerned they were as drought-resistant as sorghum and their stomata made a good recovery from droughts which would severely damage maize stomata. As with sorghum, the stomata did not entirely close during severe drought. This incomplete closure during drought has also been observed by Wormer, who has been working on runner varieties of the groundnut in West Africa for the Institute de Recherches pour les Huiles et Oleagineux, Paris.

39. Since there was little likelihood that restricted carbon assimilation, due to stomatal closure, was an important factor in reduced yields following drought, the habit of the plant was more closely observed. The results indicate that yield loss is almost entirely due to the physical loss of flowers and pegs. These are undoubtedly sensitive to both soil and atmosphere drought and if they wilt severely, no crop results. Fortunately, flower production is spread over a long period, so that a succession of flowers develop and some may escape the worst of the drought. Thus the crop is essentially a drought evader by two processes, one by the ability of its stomata to recover from drought, the other by its successive production of flower and fruit. Both contribute to the reputation of the plant as being fairly drought resistant.

40. Studies of the behaviour of maize stomata were resumed when four drought resisting varieties of maize were kindly supplied to me by Drs. Harrar and Wellhausen of the Rockefeller Foundation. They were recommended by Dr. Wellhausen as some of the most drought-resisting in the climate at this Office of Special

Studies in Mexico. They seem very promising indeed. By chance they have been tested in East Africa sooner than expected. They were planted in July in the grounds of this Organization so that their habits could be observed before later planting to take advantage of the severe drought expected in the hot, dry season (January to March). Instead of receiving the usual sequence of light rains sufficient for reasonable growth they were faced with prolonged natural drought. In four months they received only some three inches of rain, which fell on some 25 days, so that any break in the drought was slight. They resisted these severe conditions and gave a small crop. In addition, they did not appear to suffer from water strain, for a daily record of stomatal behaviour was maintained throughout and no sign of stress was shown by the stomata.

41. Some of the original seed has been supplied to the maize breeders of the Tanganyika and Kenya Departments of Agriculture.

Leaf Temperatures

42. Dr. H. Barrs, a plant physiologist who has recently been appointed to the Katherine Research Station in Australia, worked in this section for some weeks in order to gain experience with techniques and equipment used in the study of field problems. During his visit we studied, among other things, the difference between leaf temperatures of the groundnut and those of the ambient air by means of thermocouples. The groundnut plant was at all times supplied with sufficient water and continuous, daily, resistance porometer measuresments on the same plant or on neighbouring plants treated in the same way, showed that the stomata were open while temperature measurements were being made.

43. Although, in the beginning, it was found that temperature differences (t_d) could apparently be negative for fairly long periods, that is that leaf temperatures were lower than air temperatures, it was later proved to be due to faulty measurement of ambient air temperature. The reasonably accurate measurement of ambient air temperature proved to be difficult and in the end "mean" ambient air temperature was used as standard. This was obtained by drawing air from near the leaf over and around a thermocouple triple screened against direct and indirect radiation. Since all the equipment was small only a very little volume of air was required to produce the necessary velocity over the couple, so that there was little local disturbance due to this, particularly

as it was not in the main run of air over the leaf. When this was done t_d was rarely found to be negative and when it was negative it did not so persist for long. Thus there is apparently no long continuous period when the leaf of this plant is cooler than the ambient air, at least during the day.

44. As would be expected, solar radiation dominated the pattern of behaviour but wind and saturation deficit were also found to be important. In a calm, that is when all the little flurries and local convections failed to flutter the leaves or nearby dust, and no wind was detected by the small anemometer which failed to respond when wind speeds were below some 0.4 metres-sec, then it was found that there was a very close relationship between solar radiation and t_d. In very calm, very dull, conditions t_d was always close to zero but as the sun came out the temperature of the leaf changed rapidly and t_d increased rapidly, for changes in ambient air temperatures were slower and by comparison slight. Indeed, all our regressions of t_d on solar radiation under our conditions show an accountable variance of 94 per cent or more, which indicates the closeness of the correlation. Although it is easy to show that such changes may be accounted for almost entirely by changing intensity of solar radiation, there must be some effect of changing rates of vapour transfer across the various humidity gradients which develop within the local convection currents and of disturbances due to slight winds. In a calm, such changes were not detectable by our apparatus; on the other hand they were very obvious under windy conditions. On one such day when wind speeds (u) ranged from 0.4 to 2.0 metres/sec (0.9 to 4.5 m.p.h.) and solar radiation (r) on a horizontal surface from 0.06 to 1.89 g.cal. cm^{-2} min^{-1} and saturation deficit (s) from 7 to 15 mm Hg, the following relationship was obtained.

$$t_d°C = 1.2 + 0.129u + 3.1r - 0.017e_a$$

where e_a is the evaporating power of the air, here taken simply as the product of wind and saturation deficit (u.s).

45. Each component of the regression independently proved to have a highly significant effect on t_d and, on a comparative basis, radiation proved much more important in determining the rise of temperature of the leaf than the evaporative power of the air in cooling it, while this in turn produced greater effects than wind in bringing heat to the leaf.

46. The net result is simply that the groundnut leaf on a bright windy day is generally warmer than the surrounding air, but not to any great extent, for example under the mean environ-

mental conditions of the day referred to above the mean leaf temperature was only some $1\frac{3}{4}$°C above its surroundings—and this was under solar radiation of intensity of some 1 g.cal. cm^{-2} min^{-1}, that is under fairly bright conditions.

Plant Composition

47. The joint experiments with Dr. Dougall of the Grasslands Research Station, Kitale, are nearing completion and already interesting generalizations can be made. We find, as others have found, that the percentage content of nitrogen (N), phosphorus (P), and sulphur (S) and total carbohydrate (CHO) vary with age and water status of the plant. In plants growing actively without serious check, the percentage total carbohydrate content of the dry matter increases with age, whereas the nitrogen,

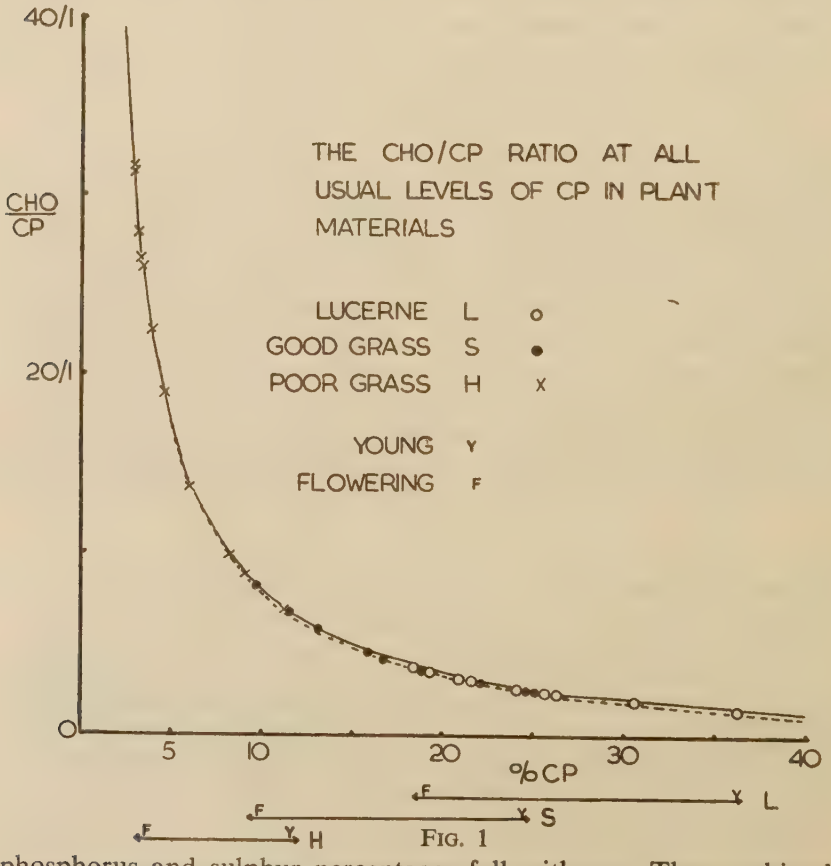

FIG. 1

phosphorus and sulphur percentages fall with age. The combined effects are most easily demonstrated by the changing ratios of one to the other. As the results will be reported in detail else-

where only one of the ratios, the total carbohydrate/nitrogen ratio, is illustrated here. It shows the common pattern which is apparently found in all plant materials which have grown normally.

48. Since carbohydrate and organic nitrogen (substantially the crude protein (6.25 N) of the animal nutritionist) make up the bulk of the dry material it can be shown that in unit weight of such material the sum of these components is approximately 91 per cent. Thus in theory CHO $\simeq$ 91 – C P. where all values are expressed as percentages of dry matter. In practice we find the following:—

From analyses of grasses and legumes (all ages and stages of growth) CHO = 91.5 – 1.2 CP.	$r^2 = 0.99$	n = 52
From analyses of fodder trees and shrubs (including twigs) CHO = 88 – 1.0 CP. ...	$r^2 = 0.64$	n = 49
From data in Schneider's *Feeds of the World* CHO = 92 – 1.3 CP.	$r^2 = 0.80$	n = 1300

which indicates good agreement between theory and practice. All the equations may be divided throughout by CP., giving the ratio $\frac{CHO}{CP}$ as a function of crude protein. Thus the theoretical equation is $\frac{CHO}{CP} \simeq \frac{91}{CP} - 1$ or as found in practice, using Schneider's records, $\frac{CHO}{CP} = \frac{92}{CP} - 1.3$. These are shown as the continuous and broken lines respectively in Fig. 1. Superimposed on them are the actual records of analyses during growth to flowering of a poor quality grass, a good quality grass and a legume. Each occupies a different portion of the general curve and each overlaps another. Thus while plants may differ in their carbohydrate/crude protein ratios during growth the different ratios all conform to a simple general overall pattern. In the same manner a common pattern of CHO/P and CHO/S ratios may be demonstrated.

49. Although the results are of interest from the plant physiological standpoint they are also likely to prove of interest in animal nutrition, for it can be further shown that there is a

relationship between the CHO/CP ratio and the nutritive ratio of animal feeding studies. The nutritive ratio is a similar ratio in terms of digestible nutrients for it is the ratio of digestible non-protein to digestible protein. We find that it may be calculated from the CHO/CP ratio by means of an equation such as the following:—

$$\text{Log NR} = 1.31 \log \frac{\text{CHO}}{\text{CP}} - 0.13.$$

This equation implies that there is a relationship between total and digestible carbohydrate as well as between total and digestible protein. This aspect has not yet been investigated.

Rainfall, Age and Yield of Fodder Crops

50. In connexion with my studies of the effect of rainfall on crops, Mr. W. R. Birch, of the Kenya Department of Agriculture Grassland Station, Molo, supplied me with the records of a fodder crop experiment which had been conducted without application of fertilizers at any period before or during growth over some 12-14 years at Kabete, Kenya. It was started in 1935 and the data have not until now been processed. The crops were of three perennial grasses as well as canna and sweet potato tops.

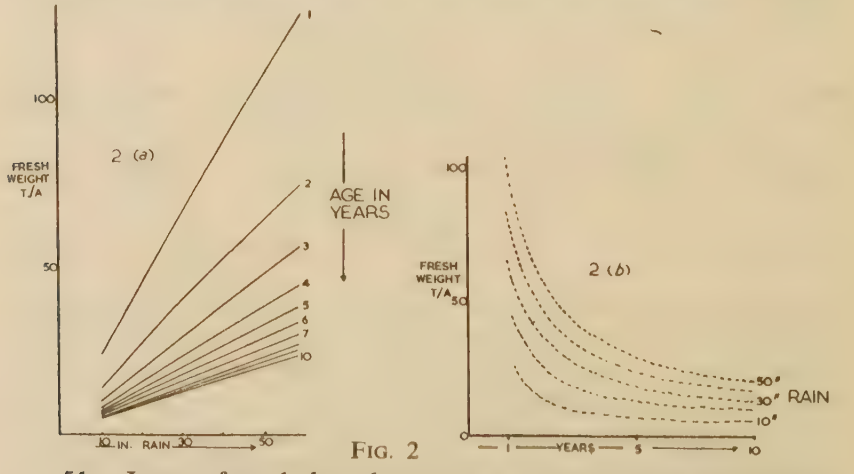

FIG. 2

51. It was found that there was a very marked relationship between the annual or seasonal yields and rainfall as well as age from planting. No matter which crop was concerned the result was as shown in Fig. 2 (*a*) and (*b*) which in different forms illustrate that the effect of increasing annual rainfall is to increase annual yield substantially linearly, within the limits of 10-50 inches a year, whereas the effect of increasing age is to

decrease yield in a logarithmic manner; yield falling off most markedly in the second year and thereafter decreasing less rapidly. Similar results have been obtained between seasonal rainfall and age. The depressing effect of age on yield is apparently the result of overcrowding and is apparently not due to loss in soil fertility, for a subsidiary experiment in which maize, an annual, was planted twice a year in the same plots over the whole 14-year period showed no apparent loss of fertility: the yields at the end of the experiment being similar to those in the beginning and throughout the 14 years.

SOIL FERTILITY STUDIES

HUMUS DECOMPOSITION AND SOIL NITROGEN

H. F. Birch and C. C. Hood

52. The effect of the period that a soil is in a dry state on the amount of mineral nitrogen subsequently produced on moistening has now been studied for a range of soils dried for different periods. Part of this work was described in the Annual Report for 1958. Seven soils were taken with approximately 1, 2, 3, 4, 5, 6 and 7 per cent C (Walkley-Black uncorrected). These were air-dried for 0, 3, 6, 9, 12 and 15 weeks and then moistened and left in the respirometer for 19 days. The amounts of carbon mineralized and mineral nitrogen produced during this period were then measured. The extra amounts mineralized due to drying were found to be a significant linear function of the logarithm of the period that the soils were in a dry state prior to moistening, as shown in Table 1.

TABLE 1

Soil	Extra N mineralized	Extra C mineralized
6·90%C	$Yn=20{\cdot}2\ X+4{\cdot}2\ (r^2=0{\cdot}997)$	$Yc=90{\cdot}9\ X-\ 8{\cdot}7\ (r^2=0{\cdot}998)$
6·28%C	$Yn=11{\cdot}2\ X+1{\cdot}5\ (r^2=0{\cdot}901)$	$Yc=32{\cdot}1\ X+\ 5{\cdot}7\ (r^2=0{\cdot}889)$
5·48%C	$Yn=\ 6{\cdot}8\ X+2{\cdot}3\ (r^2=0{\cdot}775)$	$Yc=33{\cdot}2\ X+\ 2{\cdot}1\ (r^2=0{\cdot}956)$
4·22%C	$Yn=\ 4{\cdot}8\ X+1{\cdot}2\ (r^2=0{\cdot}786)$	$Yc=43{\cdot}7\ X-19{\cdot}6\ (r^2=0{\cdot}947)$
3·14%C	$Yn=\ 5{\cdot}2\ X-0{\cdot}4\ (r^2=0{\cdot}899)$	$Yc=35{\cdot}0\ X-14{\cdot}3\ (r^2=0{\cdot}976)$
2·06%C	$Yn=\ 6{\cdot}2\ X-0{\cdot}6\ (r^2=0{\cdot}837)$	—
1·00%C	$Yn=\ 2{\cdot}6\ X-0{\cdot}1\ (r^2=0{\cdot}526)$	$Yc=11{\cdot}4\ X-\ 2{\cdot}5\ (r^2=0{\cdot}743)$

Yn and Yc are respectively the extra amounts of nitrogen and carbon mineralized (mg/100g soil) and X = the log of the number of weeks that the soil was air-dried prior to moistening.

53. The effect of drying the soil on the amount of mineral nitrogen subsequently produced on moistening can best be appreciated when the extra amounts of nitrogen produced are expressed in units of pounds sulphate of ammonia per acre 6 inches (Table 2).

TABLE 2

	WEEKS AIR-DRIED BEFORE WETTING				
%C	3	6	9	12	15
6.90	1,320	2,031	2,355	2,631	2,809
6.28	768	836	1,269	1,330	1,569
5.48	594	769	741	1,040	1,110
4.22	420	449	590	769	693
3.14	185	374	503	562	503
2.06	300	347	488	567	772
1.00	143	111	341	232	310

Table 2 serves to emphasize the importance of the climatic factor in relation to soil fertility. From Table 1 an estimate can be obtained of the effect of different lengths of dry periods both on subsequent nitrogen mineralization and soil carbon losses.

54. It has been confirmed that when a dry soil is moistened two simultaneous decomposition processes occur. The one involves organic material which goes into solution and decomposes without the production of mineral nitrogen, and the other involves decomposition at the humus surface with production of mineral nitrogen. Both processes fall off in rate after moistening in accordance with a first order reaction. Since both carbon and nitrogen mineralization are so similarly affected by drying, it appears that drying either increases the area of organic surface exposed both to solution and nitrification processes, or else it exposes fresh surfaces after each drying. The mechanism has been discussed in the 1958 Annual Report. Further evidence in support of the hypothesis has been obtained from two subsequent experiments. In one of these it was found that successive water extractions of a soil without intermediate drying produced very little organic material in the successive extracts whereas when the soil was dried between each successive extraction a considerable amount of organic material went into solution in each instance. Since successive dryings and rewettings are not cumulative in this respect this indicates that drying leaves the organic material in a physical state conducive to increased amounts going into solution. In the other experiment it was found that when solution of the organic material was depressed, through the addition of salts, nitrification was not correspondingly affected, which confirms the independent nature of the two simultaneous decomposition processes mentioned earlier.

55. To get an insight into the kind of organic material involved in the drying effect, the decomposition of plant material, and the humus derived from the decomposition, has been studied.

The results obtained have a practical bearing on the utilization of green manures. Grasses (0.5g) containing (1) 3.29%N, (2) 2.66%N, (3) 2.10%N, (4) 1.66%N and (5) 1.06%N were allowed to decompose in the respirometer in the presence of 40g of moist subsoil. After 15 days about 40 per cent of the grass had decomposed, but only (1) released any mineral nitrogen. The samples were then air-dried for three weeks and remoistened. A flush of decomposition occurred which was over after six days. During this period sample (2) also released mineral nitrogen. On again air-drying and rewetting followed by incubation (six days) samples (1) and (2) released a further amount of mineral nitrogen, whilst sample (3) produced it for the first time. A further repetition of drying and rewetting gave further releases from (1), (2) and (3), while the amounts from (4) and (5) were still less than the control (subsoil alone). Altogether the above samples were moist for 33 days, namely 15 days initially plus six days after each of the three intermediate dryings. Samples kept moist for 33 days, without intermediate dryings, decomposed to the extent of about 50 per cent but only (1) produced mineral nitrogen. When, however, after 33 days decomposition the samples were air-dried and rewetted mineral nitrogen was produced with samples (1), (2) and (3), compared with (1) and (2) only when the initial decomposition period prior to drying and rewetting was 15 days, and the amounts produced were greater.

56. It can be concluded from these results (1) that drying induces nitrification on rewetting, and (2) that a part only of the organic material formed by decomposition of the grass decomposes, with production of mineral nitrogen, after each drying and rewetting. This behaviour closely parallels that of soils following similar treatments. For the drying effect to give a release of mineral nitrogen on rewetting, it appears from the foregoing experiment that the C:N ratio of the organic moiety (plant—and bacterial—remains) must be 10 or less. The greater amount of mineral nitrogen produced when drying and rewetting followed an initial decomposition period of 33 days (compared with 15 days) is probably due to the greater reduction in the C:N ratio that occurs during the longer period, when more carbon is lost as carbon dioxide without a concomitant loss of organic nitrogen as mineral nitrogen.

57. Under field conditions, release of mineral nitrogen may not occur during decomposition of the plant material but only after decomposition is followed by a drying and rewetting, e.g. during the wet season following that in which decomposition of the plant material occurred, with a dry season in between. This behaviour is likely to occur with plant material containing 2.1 to 2.7%N.

With decreasing nitrogen contents the number of seasonal dryings and rewettings required before even small nitrogen releases occur is likely to be considerable. Thus, with samples (4) and (5), in spite of carbon losses during decomposition the C:N ratios were still too high (12.0 and 20.0 respectively), even after three dryings and rewettings, for the production of mineral nitrogen.

58. There is still some doubt as to the actual material on which the drying effect operated, i.e. whether it is residual decomposed plant material or microbial remains. Experiments involving decomposition of relatively simple organic compounds (e.g. gelatine and glucose, nucleic acid and starch) are now being carried out to solve this problem.

59. *Soil Phosphorus.* It has been found here that water extracts of a range of East African soil types contain organic phosphorus in greater amounts generally than inorganic phosphorus. The aqueous soil extracts decompose readily but without the production of inorganic phosphorus. A similar observation was reported earlier with regard to the non-production of mineral nitrogen when aqueous soil extracts decompose although organic nitrogen is present in the solution. Either there is no mineralization of phosphorus and nitrogen or the mineralized products are taken up by the micro-organisms. Another possibility is that relatively simple organic nitrogen and phosphorus compounds are utilized directly by the micro-organisms. Other workers have shown that the soluble soil organic phosphorus compounds are not utilized by the plant. It appears then that in spite of the presence of organic phosphorus in the soil solution it serves neither directly nor indirectly as a source of plant available phosphorus. Further aspects of soil extraction methods in relation to phosphate availability are discussed by M. T. Friend later in the report.

FURTHER APPLICATIONS OF THE RESPIROMETER

H. F. Birch and C. C. Hood

60. *Digestibility Studies.* In the 1958 Annual Report a close relationship was reported between the decomposability of feeds in the respirometer and their digestibility. It has since been found that decomposition of the feeds was reduced, on an average, by 83 per cent when mixed with finely divided charcoal, due to the adsorption of the soluble decomposable constituents. The production of mineral nitrogen, where this occurred, was also depressed by the charcoal, probably because of the reduced decomposition.

61. No improvement was obtained in the significance of the relationships between digestibility and decomposability using decomposition data for carbon-treated samples compared with the non-treated. The experiment does however indicate that the decomposability and possibly, therefore, the digestibility of the feeds is largely a function of their solubility.

61. *Insect Studies* (*In conjunction with T. Jones, Entomologist*). The behaviour of wood-boring Oemida larvae was studied in the respirometer. The larvae, BL (about 0.5g) and SL (about 0.25g) were placed in the respirometer vessels (8 oz. sample jars) with a piece of wood. Their activity under these conditions was followed by measuring their respiratory activity. After five days the larger of the two (BL) had exhaled 5.6 ml CO_2 and the smaller (SL) 2.24 ml. During the next five days BL produced 11.2 ml and SL 2.2 ml. These quantities were related to the amount of loose frass (digested wood) produced. The larvae were still alive and active after six weeks in the respirometer.

62. The experiment indicates that the larvae survive under the conditions of the respirometer and provide a record of their activity. The respirometer may, therefore, find applications in studies involving the effects of different substrates and wood treatments on activity and also in carbon balances between wood, frass and carbon lost as CO_2.

ADVISORY WORK

63. *Forest Department, Kenya.* Soils were collected from Kimakia Forest Station (on the slopes of the Aberdares) and Castle Forest Station (on the slopes of Mount Kenya). Because of the cold wet conditions and high acidity of these soils the growth of squatters' crops is poor. Incubation studies showed that the soils produce appreciable amounts of mineral nitrogen, but that their phosphorus and base status is very low. Burning increases the amounts of these and has been shown at Kimakia Forest Station to be effective in increasing crop yields.

64. *Pyrethrum Research Station, Molo.* Mineralization of soil nitrogen was studied, with results which may have a bearing on irrigation practices. When the soils were air-dried for one week and remoistened extra amounts of nitrogen were produced equivalent to 10 p.p.m. nitrate nitrogen or about 100 lb. sulphate of ammonia per acre 6 inches. After $4\frac{1}{2}$ weeks drying the amount was about 300 lb. A short dry period should therefore be an advantage compared with keeping the soils constantly moist.

65. *Western Province T.T.* Mineral nitrogen changes during the course of a wet season were followed in sandy low humic soils of the Kikungu and Lusenye types. The amounts of mineral nitrogen produced were low and declined as the wet season proceeded. Nitrate production in the Kikungu soil was particularly poor, indicating that nitrate-producing organisms are few or inactive.

66. *Bukoba T.T.* The production of mineral nitrogen in these base-deficient soils was little affected by the addition of bases and trace elements, separately and together. Nitrate production in the soils appears to be poor.

STUDIES ON SOIL PHOSPHORUS

M. T. Friend

67. Studies on soils from the Highland Fertilizer Scheme (Wheat, 1950) continued and were extended to soils from fertilizer trials on grasses. The total phosphorus and organic phosphorus fractions in the soil gave the best correlations with crop responses to superphosphate. The correlation coefficient for the regression of response on organic phosphorus was -0.51 and was significant at the 1 per cent level. It was considered that this total organic phosphorus represents the reserve of phosphorus in the soil and that factors which govern its mineralization, and hence its availability to plants, required further study.

68. One of these factors is the ability of the soil to retain phosphorus in the inorganic form; the phosphorus available on mineralization to the plants will be governed to some extent by how much of the mineralized phosphorus is adsorbed by the soil and rendered less available to plants.

69. The total organic phosphorus figures were modified by taking into account the phosphorus retention capacity of the soil; the value thus obtained was termed the "available mineralized phosphorus". The relationship between crop response to phosphorus and "available mineralized phosphorus" was a slight improvement over the one using total organic phosphorus only. A similar slight improvement was obtained with some soils analysed from fertilizer trials on grasses; both grass response and the percentage phosphorus in the grass were related to "available mineralized phosphorus" rather than to organic phosphorus alone.

70. Some of the soil characteristics responsible for phosphorus retention were investigated. The clay content and the total sesquioxides in the soil are significantly related to phosphorus retention ($r = 0.82$ and 0.80 respectively). When the total sesqui-

oxides were analysed for their iron and aluminium oxide contents, the total Fe_2O_3 and Al_2O_3 gave significant correlations with phosphorus retention ($r = 0.82$ and $r = 0.76$). Since the Fe_2O_3 and Al_2O_3 contents are in themselves significantly interrelated ($r = 0.92$), the above correlations may be artificial.

71. Testing by means of a multiple regression showed that the Fe_2O_3 significantly affected the relation when the effect of Al_2O_3 was eliminated, whereas Al_2O_3 did not affect the phosphorus retention when the effect of Fe_2O_3 was eliminated, showing that the Fe_2O_3 played the dominant role in phosphorus retention in the acid soils studies.

72. The "free" iron and aluminium oxides were determined by extraction from the soil with an acid oxalate solution. The correlation between phosphorus retention and free $Al_2O_3 + Fe_2O_3$ was again significant ($r = 0.62$); when the free Al_2O_3 was eliminated, the correlation was still significant for the free Fe_2O_3 ($r = 0.50$), but when the free Fe_2O_3 was eliminated, there was an inverse relationship with the free Al_2O_3, showing that the free iron oxides and not the aluminium oxides are important in the retention of phosphorus by these soils.

SULPHUR DETERMINATIONS IN SOILS AND PLANTS

M. T. Friend

73. The method of Butters and Chenery (Analyst. *84,* 239, 1959) was used to determine total sulphur in both soils and plants. For soils the method proved completely satisfactory and no difficulties due to undestroyed colloidal organic matter was encountered (*see* E.A.A.F.R.O. Annual Report 1957, p. 26).

74. For plants, the method gave rapid reproducible results; it was compared with another method (Belcher, *et al.* Chem. and Ind. 127, 1954) where sulphate is precipitated as its barium salt and the barium estimated by titration with EDTA. Good agreement was obtained between the two methods, both when the plants were ashed in the usual manner and when the sample was oxidized in a bomb calorimeter. The solutions of "bombed" samples were kindly supplied by the Grassland Research Station, Kitale. The method using EDTA was not satisfactory for soils because of their much lower sulphur content.

A CHEMICAL LIGHT METER

M. T. Friend

75. Further to the report on this light meter (E.A.A.F.R.O. Annual Report 1958, p. 27), it has been found possible to measure spectrophotometrically the concentration of anthracene in benzene without dilution at a wavelength of 400 mμ. Good agreement between residual anthracene concentration and radiation as measured on a Kipp Solarimeter in g.cals. cm^{-2} was obtained ($r^2 = 0.988$). This makes for the much easier estimation of anthracene in a large number of sample bottles.

76. *Visits.* A visit was paid to the Grassland Research Station, Kitale, where assistance was given in setting up a Flame Photometer and preparing it for the determination of Sodium, Potassium and Calcium in plant materials.

ANALYTICAL SERVICES: CHEMICAL

M. T. Friend, C. C. Hood, L. Nganga and P. Mungai

77. *E.A.A.F.R.O. Soil Survey Section and Ecological Survey (Professor Heady).* 120 soils from Ngorongoro Crater area, Serengeti Plains, Kisinga Channel and the Mara River area were analysed for pH, organic carbon, nitrogen, carbonate, coarse and fine sand, silt and clay, and the conductivities of 1 : 5 soil to water suspensions measured.

E.A.A.F.R.O. Soil Physics Section

Seventeen soils were submitted for mechanical analysis into four fractions (coarse and fine sands, silt and clay).

E.A.A.F.R.O. Spectrochemistry Section

Thirty-two soils from Eldoret and Nachingwea were analysed for pH, carbon and nitrogen in conjunction with trace element analyses by the Spectrochemistry Section.

E.A.A.F.R.O. Ecologist

Thirteen soils from Kitwe, Northern Rhodesia, were analysed for pH, carbon and nitrogen.

Forestry Departments

Twenty-six soils from Forest Departments in Kenya and Uganda were analysed for pH, carbon and nitrogen. Certain samples were analysed for phosphorus, and studies using the soil respirometer were carried out on some of these soils.

Other soils analyses included six for the Empire of India and Ceylon Tea Co., three pyrethrum soils, 12 soils for Mr. R. Walker of Kikuyu, and three soils from Narok used by cattle as a salt lick. Total sulphur was determined on eight soils from wattle plantations near Eldoret and on 31 soils from the Highland Fertilizer Scheme.

ANALYTICAL SERVICES: SPECTROCHEMICAL

G. T. Chamberlain, A. J. Searle, C. A. Spinage and M. D. Lamb

78. The Division has continued the analysis for bases and trace elements of samples received from Territorial Departments and other E.A.A.F.R.O. Divisions. During the year the post of Laboratory Technologist (Spectrochemist) financed by the Coffee Board of Kenya in the Department of Agriculture was filled by Mr. M. D. Lamb who assumed duty in July. By mutual agreement Mr. Lamb is seconded to the Spectrochemistry Division, E.A.A.F.R.O., to carry out trace element analyses for the Coffee Research Station, Ruiru, Kenya, using the equipment of this Division. By this means the Coffee Research Station has been able to commence a detailed study of the trace element status of the coffee plant.

79. Analyses during the year have totalled 153 soil extracts for bases, 261 extracts of 182 soils for trace elements, 220 plants for trace elements and 19 samples of milk, blood and borehole water.

80. Important modifications in technique were instituted during the second half of the year and these have involved complete recalibration of trace element methods involving both the direct burning of plant ash and the use of chemical concentration. This has caused the number of samples analysed to be slightly lower than would otherwise have been the case but the benefit derived from the modifications is that it is now possible to analyse nine samples where previously a batch of only six could be dealt with at a time. The first stage of these modifications was described in the 1958 Annual Report where it was stated that the use of a three-step filter in the spectrograph and the "Respecktra" calculating board had been applied to the plant ash method. In August a new three-step filter to our own dimensions was received and recalibration of intensity ratios for the plant ash method was carried out using this filter and palladium as internal standard instead of silver and chromium.

81. Similar modifications have now been incorporated in the concentration method and the improvement is illustrated by the fact that for the evaluation of 13 elements in six samples nearly 500 spectrogram line density readings were required whereas now only 220 line densities are needed for the evaluation of the same elements in nine samples. Recalibration has involved 242 exposures of standard mixtures for the plant ash method and a further 223 for the concentration method. For a period of six weeks it was necessary to cease completely the analysis of samples but after this period analysis was restarted on a reduced scale and then increased until by the end of the year a normal flow was resumed.

82. *Bases in Soils.* One hundred and fifty-three soil extracts were analysed during the year of which 61 were for the Ecologist, E.A.A.F.R.O., 48 in connexion with his study of the effect of burning vegetation on soil and 13 from other investigations. A further 53 samples were for Professor H. Heady of the University of California School of Forestry who was carrying out a study of range management in East Africa. These samples were collected from the Ngorongoro Crater, Tanganyika, and the Kasinga Channel, Uganda. The remaining analyses were routine tests in fertility studies.

83. *Trace Elements in Soils.* The balance of about 30 soils of the profiles submitted last year by the Kawanda Research Station, Uganda, were completed using both acetic acid and E.D.T.A. (di-amino-ethane-tetracetic acid, di-sodium salt at pH 7) solutions. In none of the soils was the cobalt value as low as those obtained for certain soils in Kenya and Tanganyika.

84. A similar study of the main soil types of Tanganyika has also commenced although in the first instance analysis has been mainly of surface soils. Samples were provided by the Soil Survey Division and were selected as being the major types from the more important agricultural areas of Tanganyika. Acetic extracts of 55 such soils have been analysed and low cobalt areas have been revealed in the Newala, Rungwe, Mbeya, Njombe, Bukoba, Itigi and Tabora districts.

85. Investigations into the efficiency of various extractants have continued and have included ammonium acetate at various pHs, the use of 0.05M E.D.T.A. di-sodium salt solution adjusted to pH7 and at its natural pH (c. 5.2) and the di-ammonium salt of E.D.T.A. at its natural pH (c. 5.2). The last reagent was suggested by the Cambridge laboratory of the National Agricultural Advisory Service, England, and is claimed to produce a soil-extractant

mixture which is easily filtrable while remaining equally effective in the extraction of trace elements. This has been confirmed on a variety of East African soil types and this extractant represents a considerable improvement on the di-sodium E.D.T.A. at pH 7 with which centrifugation is necessary to separate the clay particles from the solution. It was found that the di-sodium E.D.T.A. at at pH 5.2 behaved in a manner similar to the di-ammonium salt, but filtration was slower. During the year 128 extractions have been carried out using various forms of E.D.T.A. and arising from these experiments it was decided that extraction with di-ammonium E.D.T.A. at pH 5.2 would be adopted for routine use.

86. For investigating the extraction of trace elements by ammonium acetate solution at various pHs, six soils were selected, there being three acid red earths from Nachingwea, Tanganyika, two volcanic ash soils from Naivasha, Kenya, and one brown loam from Molo, Kenya. These soils covered a wide range of trace elements concentration. The general results of extraction at pH 4.45, 5.0, 6.0, 7.0 and 8.0 was that for cobalt nickel, zinc, lead and beryllium the amount extracted increased from pH 8 to pH 4.45 at which value results were similar to those for acetic acid extraction. Vanadium increased in the extracts from pH 7 to pH 4.45 reaching values consistently higher than those for acetic acid and there was some indication of increases occurring when the pH was increased to 8. Molybdenum extraction increased as pH increased.

87. Acetic acid extracts of a further 19 soils from pot tests at the Scott Agricultural Laboratory, Kenya, have been analysed and also seven typical coffee soils supplied by the Department of Agriculture, Nyasaland. The latter bore a close resemblance to similar soils from the three East African Territories.

88. Analysis of samples from the Southern Region Research Centre, Nachingwea, Tanganyika, has continued and this year the only soils to be received were from a 40-foot profile and two surface soils. At the request of the Animal Husbandry Division, E.A.A.F.R.O., visits were made to the Kitale Agricultural Experiment Station and some farms in Kenya to select soils and pasture samples in connexion with animal nutrition problems. The results of these and the Nachingwea samples are discussed below.

89. *Trace Elements in Plants.* Eleven samples of clover from trace element experiments at the Grasslands Research Station, Marindas, Kenya, have been analysed. *Trifolium tembense* when

treated with molybdenum, zinc and sodium chloride showed a threefold increase in yield over control and treatments were reflected in increased concentrations of the elements in the samples. Field data indicated that the sodium chloride treatment was primarily responsible for this increase in yield. Application of phosphatic fertilizer alone gave a tenfold increase yield and the trace elements in addition gave a further increase to bring the yield to 11 times that of control. Treatment of *T. subterraneum* var. dwalgamup with boron and magnesium gave an increase in yield whereas either alone tended to depress yield. No increase in the boron concentration in the clover was observed. Other treatments with molybdenum and zinc did not affect yield or the concentration of zinc in the samples but there was an increase in concentration of molybdenum. Combined treatment with Mg, B, Zn and Mo caused an increase in the concentration of Mg and Mo in the clover but not of B or Zn. Further samples of P + Cu + Mg treatment and control revealed an increase in uptake of Cu and Mg but no increase in yield.

90. The Southern Region Research Centre, Tanganyika, has this year submitted for analysis 32 plant samples from experiments being carried out at Nachingwea. Nine samples each of groundnut and maize leaf were taken from a liming and crop rotation experiment, the groundnuts being from blocks which had grown maize the previous year and vice versa. There were three blocks of each crop and treatments were control, 1 ton and 3 tons of burnt lime per acre applied before the previous year's crop. Striking differences in the uptake of cobalt, nickel and to a lesser extent manganese and molybdenum by the two crops were observed. Analysis of the soils of the area had indicated high available cobalt, nickel and manganese and low molybdenum. For groundnuts, the cobalt and nickel concentrations ranged from 2-10 p.p.m. in crops from both years while for maize, whether grown before or after groundnuts, concentrations were below 1 p.p.m. except for one cobalt value and four nickel values. The treatment with lime, which last year caused some reduction in the manganese concentration in groundnut leaf had not caused similar reduction this year when grown in the other blocks. The maize grown in the same blocks as the groundnuts which had shown the manganese effect also showed a similar and greater effect. Samples from control plots gave 150-250 p.p.m. Mn, the L1 treatment 90-110 p.p.m. Mn and the L3 treatment 60-90 p.p.m. Mn. Also there were indications of a reduction in the uptake of cobalt due to liming.

91. In the case of molybdenum the maize samples from both years had higher concentrations (0.1–2 p.p.m.) compared to the groundnuts (0.02–0.3 p.p.m.) and in every block each year both crops showed increases in molybdenum due to liming. From the fact that groundnuts have grown well and maize badly in this experiment the tolerances and requirements of these plants to some trace elements are well illustrated. Other samples from Nachingwea which have been analysed are maize, groundnuts and sorghum from dung-ash, farming systems, and lime-nitrogen experiments respectively. Analysis is to be carried out on further samples from these experiments at Nachingwea.

92. The visits to farms for the Animal Husbandry Division resulted in the sampling of soils and pastures in the Kipkarren, Soy and Rumuruti areas of Kenya. The soil samples from Kipkarren and Soy gave acetic acid soluble cobalt figures which appeared adequate (0.18–0.9 p.p.m.) but this was not reflected in the pastures all of which contained less than 0.09 p.p.m. Co, that is, marginal or deficient. The Rumuruti samples were from ranches concerned with the importation of Santa Gertrudis cattle and the survey indicated soil cobalts of 0.09–0.24 p.p.m. (acetic acid soluble). Cobalt in the pasture ranged from deficient, 0.04 p.p.m. (two samples) through marginal 0.05–0.09 p.p.m. (three samples) to just adequate 0.11–0.16 p.p.m. Co (three samples). Copper was marginal (4–5 p.p.m.) in three pasture samples and adequate in the remainder.

93. Prior to the arrival of Mr. Lamb 56 samples of coffee leaf had been analysed during the year for the Coffee Research Station, Ruiru, Kenya. Thirty-six of these samples were from a zinc chelate trial and no significant change in composition was observed. Samples of young and old leaf each showing "debilitated", "hot and cold" and normal healthy symptoms were analysed and the only difference was that the zinc in the old leaf samples (6–10 p.p.m.) was in each case lower than that in the young leaf (13–19 p.p.m.). Coffee growing in the Mount Elgon area of Kenya had boron concentration of approximately 250 p.p.m., these being the highest recorded in this laboratory for any plant species grown in East Africa.

94. The analysis of coffee leaf samples for Kenya has been taken over since July and following his training and assisting in the recalibration programme by Mr. Lamb. Thirty-three samples have been analysed for complete trace elements, these including further samples from the Kitale area, samples from a trial involving "Sea

Magic" fertilizer and other samples from experimental work being carried out at the Coffee Research Station. Further, Mr. Lamb has analysed for iron and manganese 14 samples from a ferrous sulphate -iron chelate trial and 12 samples for zinc only from a zinc chelate trial.

95. Other coffee samples have been analysed for the Coffee Research Station, Lyamungu, Tanganyika, and for the Mycologist, E.A.A.F.R.O.

96. For the Horticultural Division of the Department of Agriculture, Kenya, six samples of chlorotic and healthy leaf from plum trees in the Molo area were analysed. Little difference between the chlorotic and healthy leaf was observed and arrangements were made for further samples to be taken over the three-month period prior to cropping when chlorosis is stated to be at its worst. Also chlorotic and healthy leaf from orange and lemon trees at the Horticultural Station, Thika, were analysed and again little difference between samples was detected.

97. Other plant analytical work has included two pasture samples for the Animal Health Research Centre, Old Entebbe, Uganda, and tree leaf samples for the Forest Department, Uganda. Also in connexion with milk taint the change in composition with season of star grass pastures and other feeding stuffs has been followed for the Veterinary Experimental Station, Naivasha, Kenya.

98. *Miscellaneous Analysis.* In addition to the Naivasha pastures routine milk samples have also been analysed with the object that should taint occur some change in composition might be detected. Due to poor rains no severe taint was experienced. A sample of milk from the Kitale Agricultural Station was analysed. Borehole water was also analysed from Eldoret and the Rumuruti farms mentioned above. Attempts were made to determine molybdenum and other trace elements in blood and while molybdenum could be detected easily at a level of approximately 0.02 p.p.m. an accurate analysis was not possible due to the lack of a certain reagent. This investigation will be resumed on receipt of the required reagent.

99. Another analytical experiment involved the removal of phosphate from the solution of samples such as bone and similar materials as this interfered with the concentration technique normally employed. Ion exchange was satisfactory in the absence of chloride but the presence of this radical in either acid or neutral

solution inhibited the removal of phosphate such that the method was impracticable with the resins available. Some success, however, has been achieved by precipitation the phosphate from acid solution using zirconyl chloride but more experimental work is necessary.

SOIL MICROBIOLOGY

M. A. Ledger and Chege Mugani

100. Dr. Millbank resigned from the post of Microbiologist at the end of his tour in March, 1959, and his successor has not yet been appointed. As a consequence, the work in progress has been concerned with finishing off some projects which were not completed when he left.

101. The principal problem being completed concerned the possibility that wattle nodule bacteria may be able to form effective nodules on lupins, for lupins growing on the Muguga Farm nodulate very heavily even on land which has been under wattle for nearly half a century, and before that under indigenous forest. Considerable difficulty was found in getting the wattle nodule bacteria to grow well in pure culture and to get sterilized seeds of wattle to germinate, but these have now been overcome. The technique of inoculating wattle seedlings with wattle nodule bacteria is also satisfactory.

102. A number of these wattle bacteria isolates were then inoculated onto various species of lupins and vetches growing in Roux tubes, but in no case were any nodules produced. But it was also found that if lupins were grown in sterile vermiculite and inoculated with surface sterilized wattle nodules some of the lupin roots became nodulated, although none did in the control plots. These experiments are being repeated.

103. Some trials have also been made to test the effectiveness of inoculating leguminous crops in the field by mixing the seed with a culture of the nodule bacteria adsorbed on vermiculite instead of the usual method of sprinkling a liquid culture on the seed. The method was suggested by C. Bonnier of I.N.E.A.C. and our preliminary results show that it may be superior to the usual methods.

SOIL SURVEY

R. M. Scott and Stephen Kamau

104. Mr. R. M. Scott was on home leave from July to December, so this report is mainly confined to the first six months of 1959.

105. *Second Provisional Soil Map.* The Kenya Atlas was being prepared by the Surveys of Kenya towards the end of 1958 and the early part of 1959; the Soil Survey Section was asked if it could produce a soil map to be included in this Atlas. This request was agreed to, and an amended copy of the Kenya portion of the soil map, compiled by Gethin Jones and Scott was submitted. The amendments were carried out with the help of Mr. E. Bellis and Dr. J. Thorpe of the Scott Agricultural Laboratories, who were also able to fill in certain blank areas in the Northern Frontier District not visited by the authors.

106. Having had the Kenya portion of the soil map published, it was decided to ask the Chief Research Officer, Tanganyika, if it would be possible to have the Tanganyika portion included in the Tanganyika Atlas as an extra sheet. This was agreed, and a copy has been sent to the Chief Research Officer.

107. A copy of both the Kenya and Tanganyika soil maps was also sent to Dr. D'Hoore at Yangambi to help in the compilation of the Soil Map of Africa.

107A. *Soil Classification.* In conjunction with the production of the Kenya Atlas Soil Map, a classification was drawn up, with slight modifications, based on "A Brief Description of Soil Classes" presented by the Soil Survey Section at the Soil Fertility meeting held at E.A.A.F.R.O. in March, 1958. The modifications consisted mainly in altering the order in which the soil classes occurred, rather than in altering the soil classes themselves, as this would have meant redrafting the map. For this Mr. Scott is very grateful to Mr. E. Bellis and especially to Dr. James Thorp whose knowledge and wide experience were a great help.

108. The soils were first separated on drainage, falling into the following categories:—

A. Well drained soils.
B. Soils with slight seasonal impeded drainage.
C. Seasonally waterlogged soils.
D. Soils with impeded drainage.
E. Poorly drained soils.

There was also another category allowing for lithosols and regosols.

109. The well drained soils have also been subdivided into present climatic regions as follows:—

1. Humid regions.
2. Subhumid regions.
3. Semi-arid regions.
4. Arid regions.

It was felt that this system of classification, could more easily be translated into land use. Attempts, where possible, were made to classify these soils on the American system based on the category of "Great Soil Groups".

110. *Soil Surveys.* As stated in the 1958 Annual Report it was hoped to complete the soil map (scale 1 : 50,000) of the Nairobi area in 1959. The original area consisted of four 1 : 50,000 sheets and this was extended eastwards to include part of the Machakos-Kitui Districts in order to collaborate with the Ecology Section in their proposed vegetation and land use survey, which was to be carried out in conjunction with the Kenya Agricultural Department. This work has almost been completed and now requires writing up.

111. Also in collaboration with this Ecology Scheme, print lay-downs were received from the Department of Overseas Surveys and the Black Clay Plains were deliniated on them. This entailed examining aerial photographs of the area with checks in the field.

ECOLOGY

C. G. Trapnell

VEGETATION—LAND USE SURVEY OF SOUTHERN KENYA

112. Reconnaissance studies of southern Kenya vegetation, recorded in the last two Annual Reports, are being followed by a detailed vegetation survey of southern Kenya. This is being carried out in collaboration with the Directorate of Overseas Surveys and the Kenya Department of Agriculture with the object of mapping the elaborate climatic pattern of vegetation types in southern Kenya for purposes of land use interpretation. Two officers are being seconded to help in the project, Mr. M. A. Brunt, Land Use Officer of the Directorate of Overseas Surveys, and Mr. W. R. Birch, Pasture Research Officer of the Department of Agriculture. The Survey will cover an area of 40,000 square miles, which will include all the areas of high potential in Kenya other than the coastal strip. The vegetation interpretation is being carried out with the aid of air photographs and its results will be plotted initially on print lay-downs on the scale of 1/135,000. The data from the lay-downs will subsequently be compiled at the Directorate of Overseas Surveys in the form of a four-sheet map at the scale of 1/250,000.

113. Work during the first part of the year was largely concerned with preliminaries for this survey and with preparation of earlier studies for publication, the writer being on overseas leave from the end of March to mid-September. During this period the Directorate of Overseas Surveys completed the preparation of the 30 print lay-downs needed to cover the survey area and compiled the four topographic base maps, as well as providing much necessary equipment, and their unstinted help is gratefully recorded.

114. Field work for the survey was begun in Kitui and Machakos Districts following the arrival of Mr. Birch at the beginning of November. Mr. Brunt arrived at the beginning of December and is expected to be with the survey for eight months. Completion of the four map sheets involved is not anticipated until 1961. It is hoped that they will provide a detailed representation of the various ecological zones of each region against the present pattern of land use, and their production is intended to be combined with a study of meteorological and other factors affecting the ecology of each area. A preliminary study of rainfall-altitude relations and their influence on differing climatic series of vegetation types has meanwhile been completed for publication.

PLANT IMPROVEMENT AND PROTECTION

CASSAVA BREEDING

H. H. Storey and Barnabas Kifua

115. This project was reviewed in the 1958 report. Breeding has now been discontinued and work during the year confined to the maintenance of selected clones at Amani, and their distribution to agricultural stations.

116. It is planned to discontinue the cassava activities at Amani by the end of 1960, in the expectation that all interested agricultural stations will by then have received material. A collection of selected breeding material, including parents of the most promising clones developed in the past, will be retained at Serere, Uganda, under Mr. Doggett's control.

GENETICS OF RESISTANCE IN MAIZE TO THE VIRUS OF STREAK DISEASE

H. H. Storey and A. K. Howland

117. Studies have continued during the year following the general lines outlined in previous reports. When this work was started it was hoped that the juvenile-testing procedure might afford a simple genetic picture, as we had found in studies of resistance in maize to the rust, *Puccinia polysora*. It now appears unlikely that this hope will be fully achieved; but, nevertheless, advances made indicate that a plan for breeding resistant maizes could now be formulated.

118. Our method for testing families has been as follows. Insects of an "active" race of the vector, *Cicadulina mbila*, were fed for not less than four days on a fully streaked leaf of a susceptible maize; they were then distributed, two at a time, into a type of leaf cage that could be clipped on to the first leaf of each young seedling to be tested. If the seedling was susceptible, characteristic streak symptoms appeared on it within a week; if at the end of this time no symptoms had appeared, the seedling was exposed to a second infection by a new pair of insects. It rarely happened that the first infection failed with susceptible plants; but with more resistant ones the retest sometimes gave symptoms where the first had failed.

119. Experience has revealed difficulties in classifying the range of streak reactions, and these difficulties have not yet been fully resolved. Our procedure has been to classify the test seedlings at 20 days, and more recently at 30 days; then to transplant selected plants from each family and grow these to maturity. At one end of the scale, the young seedling showing the most severe reaction normally remains severe up to tasselling, although there is always a tendency for the frequency of the streaks to lessen on the later formed leaves. At the other end, the plant that shows no streaks after two tests normally shows none throughout its growth. Exceptions occasionally occur, and among the "intermediate" plants—those showing a more or less sparse distribution of streaks on the leaves formed up to 30 days—the condition of the last leaves before tasselling is not certainly predictable. Thus a plant fairly strongly streaked at 30 days may show a marked reduction in streaking in later formed leaves; or, alternatively, the streaking may be intensified.

120. It is probable that the condition on these last-formed leaves is the best criterion of a plant's resistance to the virus. Glass-house space, however, restricts the number of selections that can be made from each family. Interpretation of family ratios based on 30-day records is consequently subject to some uncertainty.

121. From the start of our work we realized that what is called the streak virus might not be a single entity but a group of virus strains. Our original infection plants were believed to be carrying virus from several sources. In an attempt to isolate separate strains from this virus mixture, if, indeed, it were a mixture, insects were allowed to take up virus from individual spots on leaves of infected seedlings, usually the first formed spots after infection and usually on seedlings having a high resistance. As soon as breeding had produced resistant maize lines that could be used as indicators, the several supposed virus sub-strains so isolated were tested. There was no indication that, in fact, any difference existed between these sub-strains.

122. At the same time a search was made for strain differences in field-streaked plants from various localities. Again, no difference could be detected, except in one possible instance. Here the virus, from a site in Tanganyika, appeared to have the capacity to produce a moderately severe disease in some plants of maize lines that had been highly, and nearly uniformly, resistant to the original virus. This aberrant behaviour is still under study; it is possible that we may have found a strain of the streak virus more virulent than that previously used in our experiments. If this

proves to be true, it will clearly influence conclusions that we have reached and their practical implications; but confirmatory experiments are necessary before we can be sure of the facts.

123. Progress in breeding has been as follows. Selection in lines supplied by Dr. Gorter from Pretoria gave in the first and later inbred generations families that were very highly resistant to the standard virus that we have employed, showing after infection in the early seedling stage either no symptoms whatever or a few chlorotic streaks characteristic of this virus but no subsequent development of the full disease. All these plants were free from any symptoms on the later-formed leaves at tasselling. In general, these inbred lines were poor plants of low productivity; but the better ones were fully adequate as parents in our genetic studies.

124. The first crosses of these inbred resistant lines with susceptible maizes gave families that were uniformly susceptible and developing the disease in a fairly severe form. Many of these families, however, grew in our glass-house conditions into large plants, carrying good ears. It is possible that hybrid vigour may have, in part, counteracted the deleterious effects of the streak virus.

125. The families from selfings of these F1 plants segregate, as was to be expected, but gave a range of reactions from fully resistant to fully susceptible. From this F2 generation plants were selected, each classed according to the severity of the streak symptoms it carried. These plants have been selfed, and the resulting families are being tested in the hope that results may show the genetic constitution of their parents. The tests were in progress at the end of the year; but early results do not suggest that a simple genetic hypothesis will emerge.

126. The indications to date are that genes giving susceptibility are dominant, and that high resistance occurs only in genotypes pure for recessive genes. Even in the absence of a simple genetic hypothesis, however, there is a case for breeding by the back-cross method to obtain locally-adapted maizes carrying resistance. An attempt will be made to carry out the early stages of such a programme at Muguga; but it will soon be desirable to transfer the work to a plant breeder on a field station in an area where streak disease is naturally prevalent.

127. As a first step towards transferring breeding to the field, arrangements have been made with Dr. A. C. Evans for a preliminary test during the 1959/60 season of some of our material at

Newala in southern Tanganyika, where streak is normally a serious problem. The primary function of this test is to determine whether glass-house behaviour in Muguga is satisfactorily reproduced in the field. Other field tests in an area of severe streak infection in southern Rhodesia have been arranged through the courtesy of Dr. G. R. Bates.

SORGHUM BREEDING RESEARCH SCHEME

H. Doggett

128. *Staff.* H. Doggett was absent from the beginning of July to the end of October on a travel grant in the U.S.A. Dr. D. Jowett joined the Section at the beginning of November.

129. *General.* 1959 was the first year in which a field crop has been grown since the sorghum section started at Serere. The land was necessarily largely occupied with the breeding material brought to Serere from Ukiriguru, and with that inherited from W. Hirst, the Uganda Government Botanist. Three plantings were made, on 4th March, 18th March and 25th June. The first two grew well, and were not troubled by disease or insect pests, although there was some bird damage. The third planting was severely attacked by Central Shoot Fly and stem borer, and a lot of material was lost. Attempts to control the pests with insecticidal sprays were made, and the help of Mr. W. Ingram, Uganda Government Entomologist, is gratefully acknowledged.

Breeding

130. *Bird Resistance.* The East African sorghum crop is subjected in many areas to serious bird damage, and in such areas unpalatable grain types have to be grown, usually brown in colour. Large areas of brown grain have been grown successfully for many years, but with increasing education and changing tastes, the population are less willing to use relatively unpalatable sorghum grains for food. This problem is being approached from two angles. The first approach is to attempt to breed varieties which will have palatable grains in combination with characters making them more troublesome for the birds to feed on. Any resistance of this type is relative, and is based on the fact that birds do not normally take the brown grains, so there must be sufficient grass seed and other alternative food available. The second approach is to find methods of processing the brown grains so that an acceptable flour can be produced. Pearling or decorticating machines will be of value here.

131. The characters being used for bird resistance are large glumes enclosing the grain, long awns, and pendant heads. (Goose neck.)

132. The large glume material is based on Feki Mustahe from the Sudan and also on a natural hybrid from double dwarf Shallu. There is, in addition, material selected by W. Hirst, in varieties from Lake Chad. The 1959 progeny rows included derivatives of the 1954 crosses between Feki Mustahe and weevil-resistant palatable grains of Wiru origin: derivatives of the 1955 crosses which were back-crosses of the 1954 hybrids to the Wiru grain type: and the 1956 crosses which were intercrosses between various 1955 crosses. This last group was in the F_3 generation, and showed some satisfactory grain and glume combinations. The derivatives of the cross 56 × 53 were particularly good, glume lengths of different rows varying from 9.3 mm. ±1.48 to 11.9 mm. ±1.12, glume breadths from 3.4 mm. ±0.66 to 4.0 mm. ±0.46, and awn length from 8.0 mm. ±2.1 to 11.5 mm. ±0.75. Grain cover was good and threshing easy, but the plants were rather tall, mostly over 2 metres. Yellow weaver birds were observed squeezing the green grain out of the glumes, but there was no opportunity to observe any *Quelea* attack on them. Other large glume material continued to be carried as mixed bulks.

133. The best source of awn so far has been Belko from West Africa, and backcrosses from this yielded some selections with awns 14 to 16 mms. in length. It was of interest to find that certain of the large glume crosses, which contained no material in their parentage with especially long awns, are showing good awns in the progeny. 56 × 25 produced three F_3 rows with awns 13 to 16 mm. in length. It seems that the combination of large glume and long awn will be easy to obtain, as would be expected. Breeding bulks of mixtures of long-awned material from various sources were continued.

134. A number of pendant-headed types were included in the selections taken.

135. *Tetraploid Sorghum.* Hybrid sorghum has been responsible for a big extension of sorghum growing in the U.S.A. Tetraploid sorghum offers a possible method of obtaining some of the benefits of hybrid sorghum without the need for annual renewal of seed, in addition to other benefits.

136. Restoration of fertility is one of the problems to be overcome with autotetraploids. The initial work with the autotetraploid cross 4N × 5 has been reported. This cross showed a sharp increase in seed set in the F_1, and selection for high seed set has been continued. The F_5 and the F_6 generations were grown this year. Seed sets so far are shown in the following table:—

	Parent A	Parent B	4N x 5F$_1$	F$_2$	F$_3$	F$_4$	F$_5$	F$_6$
Percentage seed set, all material	32·4	18·4	65·1	66·5	56·3	74·8	70·5	78·3
Angular transformation ..	34·8	25·0	53·7	54·8	48·3	60·1	57·3	62·5
S.E.	8·2	7·1	9·9	8·1	9·0	6·3	9·1	4·3
Corrected for diploid set..	48	34	81	82	72	78	73	78
Seed set, best family, corrected for diploid set ..			..	82	86	83	81	80

The regression of seed set on generation from F_1 to F_6 is $6 = 1.808 \pm 0.996$, and so is not significant.

137. The results so far suggest that, following the initial jump in seed set of the F_1, selection has resulted in the isolation and purification of lines with high seed set, but has not resulted in any increase in seed set over the original F_2 selections. (The standard error for the F_5 is high owing to midge damage on an out of season crop.) The tetraploid set is some 15 per cent below that of the diploid, which is very similar to the results obtained by Müntzing for tetraploid rye. A programme of intercrossing a large number of autotetraploid sorghums from diverse areas has been commenced.

138. Sixteen other autotetraploid grain sorghum varieties were grown for increase. *Sorghum almum,* a naturally occurring tetraploid from South America, was crossed with the autotetraploid 4N × 5. Seed sets in the F_1 were 90 per cent and 87 per cent on two heads, but only 76 per cent on the third. Pollen/mother cell smears from 105 plants in the F_5 generation of 4N × 5 were made for analysis of chromosome behaviour.

139. *Weevil-resistant, High Quality Grains.* A large number of lines deriving from crosses to obtain corneous weevil-resistant grains on early maturing material were grown. These were reduced to a few to be maintained in the collection. A series of multiple crosses completed in 1957 were grown, and some selections taken for the combination of corneous grain and high head weight.

140. *Collection.* Three hundred and sixty-six varieties were maintained in the reference collection. This included a collection of cultivated and wild sorghum varieties from Northern Tanganyika. Out of only nine *S. verticilliflorum* collections made, one proved to have crossed with a cultivated sorghum, and about one-third of the plants grown were evidently hybrids. There must be a good deal of hybridization occurring between *S. verticilliflorum* and cultivated types, and it is hoped to obtain some idea of the amount of introgression in the local cultivated types. Records were taken on the collection to this end.

141. D. Jowett has commenced a study of sorghum grains, and is finding a wide range of variability in pericarp structure in the sorghums of the collection.

142. Some variety trials were run in the District variety trial centres, through the co-operation of the Uganda Department. C.11, a Chad variety which had appeared promising in parts of Uganda, was tested against the Lango sorghums L.20 and L.28. Yields are given in the following table:—

SORGHUM TRIALS

Lb./acre of grain

VARIETY	1ST RAINS			2ND RAINS	
	Katakwi	Kuju	Kaberamaido	Katakwi	Kuju
C.11	1,905	745	1,105	Nil	Nil
L.20	2,630	1,090	1,250	450	235
L.28	2,795	870	1,470	745	400
L.S.D. (·05) ..	622	178	N.S.	149	144

The C.11 was recorded as a fortnight to three weeks earlier flowering than L.20 and L.28, but more susceptible to damage by Central Shoot Fly, Lygus, and birds.

143. H. Doggett's visit to the U.S.A. was of great value. Contacts with many American sorghum workers were made, and a lot of material has been received from them. The generosity of the Rockefeller Foundation in making this visit possible is gratefully acknowledged. It is also a pleasure to record the co-operation and help received in the work on Serere from the Uganda Government and the Empire Cotton Growing Corporation staff.

STEM-PITTING CONDITION IN COFFEE

F. M. L. Sheffield

144. Work on this abnormal condition has been continued in close collaboration with Coffee Research Officers of both Kenya and Tanganyika Territory. The condition might be defined as consisting of abnormalities in the cellular structure of the xylem sometimes causing the cylinder to become fluted in outline and to show pits and furrows when the bark is peeled away. The condition is undoubtedly widespread amongst *arabica* coffee but there has

recently been a tendency to ascribe certain other abnormalities to the same cause although the cause of none has yet been identified.

145. *Effect of Stem-pitting.* There is at present no estimate of the importance of the condition to the health or yield of affected trees. No exact estimate can be obtained until the cause is known and it is thus possible to induce the condition when desired. However, a survey recently undertaken by the Kenya Department of Agriculture should show whether or not the condition tends to be associated with any deterioration. Stem-pitting symptoms have often been found in dead trees but this is probably only a reflection of the very high incidence of the condition. According to data provided by the Senior Research Officer at Lyamungu, 101 of 504 trees of a Bourbon selection planted in an experiment there in 1954, were dead in 1958. 11.2 per cent of the survivors and 11.9 per cent of the dead trees had symptoms of stem-pitting. Thirty trees out of 504 Kents also died and of these 36.7 per cent of the dead and 33.8 of the survivors had symptoms. Such figures do not indicate any relationship between death and stem-pitting.

146. My attention was drawn to certain young seedlings at Lyamungu planted in shade and unshaded, and Mr. Fernie remarked that the latter had perceptibly more flexible stems. Microscopic examination of these two groups and of some seedlings of the same batch still retained in the nursery beds showed abnormal xylem cells in all. The flexible stems showed the greatest number of small, thin-walled, abnormal cells as would be expected on mechanical grounds. Whether the abnormalities are a direct effect of radiation is not known: previously no differences had been noticed in the amount of stem-pitting seen in shaded and unshaded trees.

147. I have obtained considerable evidence that trees that for some years produced abnormal wood, later returned to the production of quite normal tissue. From external examination such trees appear quite normal. There is also evidence that the condition occurred at Lyamungu as far back as 1941.

148. *Experiments to Determine the Cause of the Condition.* Examination and experiment have failed to reveal any micro-organism that might be causing the condition. Symptoms are similar to those caused by certain viruses in other hosts and a number of experiments to test a virus hypothesis of causation have been initiated. Scions from affected trees at Lyamungu and at the Scott Agricultural Laboratory have been top-cleft grafted to healthy seedlings raised in the E.A.A.F.R.O. glass-houses. Rooted cuttings

from affected trees at Lyamungu have been approach-grafted to healthy seedlings and roots from affected trees have been bench-grafted to healthy seedlings. In an attempt to parallel symptoms produced by some viruses of *Citrus* spp., healthy scions have been grafted to an affected tree in the field and also to rooted cuttings from affected trees.

149. Histological studies have shown that cell development in the coffee tree is very easily disturbed, e.g. (1) Damage from hail or other causes results in the production of lacunae in the xylem. Abnormal cells are then produced but, finally, the whole area is again surrounded by quite normal tissues. (2) Stem-pitting symptoms are usually confined to that part of the main stem or sucker within a foot or so of the ground. Similar symptoms are also often present where capping of the main stem has occurred.) These facts led me to seek physical causes for the condition and some experiments to test such hypotheses have been set up. In the first experiment, a number of seedlings were subjected to mechanical damage. It was also thought possible that the heat and moisture generated by a heavy mulch held too closely against the stem might induce abnormal cambial activity and experiments to test this hypothesis have been designed. Mr. T. Crowe of Jacaranda Coffee Research Station is collaborating in experiments sited there to test the direct effect of insect damage.

150. *Possibly Related Abnormalities.* It has been suggested that certain other abnormal conditions seen in nurseries in plantations may be caused by virus infection. Scions from such abnormal plants have been brought to Muguga and grafted to healthy seedlings.

151. Unless it is otherwise stated, all the experiments mentioned above were initiated in the glass-houses at Muguga. Because of the limited amount of glass-house space available and because the seedlings became too large to retain in them, it became necessary after some months to plant most of them outside. To guard against extraneous infections should the cause be a pathogen, the site selected had to be far removed from any land bearing stem-pitted coffee. Some were therefore put outside in the Horticultural Nurseries at Muguga in the charge of Mr. W. B. May. This proved to be so cold that the plants grew very slowly. Subsequently, experimental plants, after a period under glass, were transferred to the Irrigation Research Station of Mwea/Tebere where they are in the charge of Mr. L. J. Collings-Wells of the Kenya Department of Agriculture.

DISEASES OF SUGAR CANE

F. M. L. Sheffield

152. Research on Ratoon-stunting disease of sugar cane would be greatly assisted if a rapid test for the presence of the disease could be found. To this end a number of well-known virus test plants and a series of monocotyledonous plants, most of which were raised from seed, have been inoculated mechanically with juice extracted from infected sugar cane. Inoculated plants have been examined for external symptoms and also microscopically for any cell abnormalities that might have been induced by the virus. No attempt was made to determine whether the test plants were symptomless carriers. So far, no symptoms have been observed in any of the inoculated plants. The test plants used included: *Chenopodium amaranticolour, Datura ferox, Gomphrena globosa, Nicotiana glutinosa, N. tabacum, Petunia* spp., *Solanum lycopersicum, Agapanthus* sp., *Allium cepa, Aloe excelsa, Babiana stricta, Cordyline indivisa, Cyperus alternifolius, Eucomis autumnalis, Freesia* sp., *Miscanthidium* sp., *Pennisetum* sp., *Saccharum spontaneum* and *Zea mays.*

153. I have recently been invited to serve on the Standing Committee for Sugar Cane Diseases of the International Society of Sugar Cane Technologists.

154. In November at the request of the Belgian Government, I visited the Congo to report on sugar cane diseases in the Ruzizi Valley and to suggest methods of control of mosaic disease.

PLANT NEMATOLOGY

A. G. Whitehead

155. The Nematologist spent six months' study leave in Europe based on the Nematology Division of the British Museum (Natural History) in London. Taxonomic investigations were carried out there on some of the more important East African plant parasitic nematodes and on related forms from other parts of the world. Visits were paid to nematological laboratories at Rothamsted Experimental Station, England, at Wageningen, Holland, and at Uppsala, Sweden, where the Fifth International Nematology Symposium was also attended.

156. During the Nematologist's absence abroad the Division was supervised by the newly appointed Assistant Nematologist, Miss E. M. Boehm, B.Sc. Valuable technical assistance was rendered by Mr. L. Kariuki and Mr. N. Kinyanjui.

157. The survey of the plant-parasitic nematodes of East African soils begun at the end of 1956 has ended and is being written up, although it will take some time to publish all the results.

Soil Tylenchida and Land Use

158. As a result of the survey of the plant-parasitic nematodes of the order Tylenchida Thorne, 1949, of East African soils, interesting and important differences between the fauna of cultivated, indigenous forest and grass soils have been discovered. These are tabulated below:—

Frequency of Plant-parasitic Genera in East African Soils

NEMATODE GENUS	RHIZOSPHERE TYPE		
	Indigenous Forest	Cultivated	Grass
Aphelenchoides	94	74	53
Aphelenchus	*28*	91	61
Criconemoides	60	20	*3*
Ditylenchus	*18*	*13*	48
Hemicycliophora	10	6	4
Hoplolaimus	4	6	8
Meloidogyne	72	85	*4*
Paratylenchus	42	*10*	*1*
Pratylenchus	*4*	26	41
Rotylenchoides	16	*0·3*	5
Rotylenchulus	34	31	19
Tylenchorhynchus	18	16	19
Tylenchus	88	84	*25*
Helicotylenchus	90	82	55
Scutellonema	28		22
Gottholdsteineria	4		5
Number of Samples Analysed	50	400	150

The frequencies in this table are expressed as percentages of the total number of analyses carried out, given at the bottom of each of the three columns. Frequencies significantly lower, for a given genus in one or two of the three types of land use given here, than the frequency of that genus in the other one or two land-use types are italicised in the table.

159. The fauna of indigenous forest and cultivated soils are of the same order of diversity and both are rather more diverse in composition than grass soils.

160. Of particular importance is the rather high frequency (72 per cent) of occurrence of *Meloidogyne* spp. (Root-knot nematodes) in forest soils which is comparable with that of cultivated soils (85 per cent). It seems likely therefore that plantation crops and annual crops grown in soils previously under indigenous forest may run the risk of subsequent attack by these pathogens already present in the soils at planting time. Although the sampling of forest soils was rather limited in extent, at least six species of Root-knot nematodes were obtained on the roots of susceptible crops grown in those soil samples under glass. These included representative populations of the more common Root-knot nematodes of cultivated soils in East Africa. It is hoped to continue observations on the Root-knot nematodes of the indigenous forests of East Africa, particularly where excisions are planned for plantation crops.

The Dynamics of the Tylenchid-nematode Complex of Two Soils Under a Range of Crops

161. An investigation of the extent to which the whole tylenchid-complex of a soil was dependent upon the species of crop planted was carried out for the first time, it is believed.

162. Two soils, a dark volcanic soil from a pyrethrum planting near Limuru, Kenya, and a Kikuyu red loam soil from a Cavendish banana planting in a well-known Kenya nursery were used in this experiment. The nematode populations of these two soils were analysed for composition and magnitude, after which each soil was thoroughly mixed. Forty-five aliquots, each of 500 c.c., were taken from each of the bulked soils and to every aliquot 500 c.c. of gravel were carefully mixed in. Each litre of the mixture was placed in a 7-inch clay pot. Nine crops—black wattle, cowpea, tomato, maize, white millet, arabica coffee, tobacco, cotton and Kenya white clover were grown from the same batches of seed in each of the soil-types with a five-pot replication per crop. Every pot received at least ten seeds of its respective crop so as to reduce genetic variability between the plant populations of pot replicates. The experiment ran for about ten months, after which the soil and root populations were redetermined.

163. The results have shown—

(*a*) that the complex is very largely affected by the crop planted;

(*b*) that the reaction between a given crop and a given tylenchid-complex is relatively constant;

(*c*) that the reaction between a given crop and one component of the complex is relatively constant;

(*d*) certain crops may cause an almost undetectable low population of a component of the complex to increase very rapidly, while others may reduce high populations to zero.

164. An exception to (*c*) above arose over the Root-knot nematode attacks on cowpea and tobacco planted in the red loam soil, which contained two root-knot nematode species. With these crops it was found that though a high population of species A occurred in one of the replicates, in another the reverse occurred, i.e. a high population of species B was associated with a low population of species A. There is apparently no simple explanation of this result.

Observations on the Tylenchid-Nematode Fauna of a Pyrethrum Field

165. The composition and population dynamics of the tylenchid-complex of a pyrethrum planting near Limuru, Kenya, were studied throughout a year. The field was randomly sampled at roughly bi-monthly intervals. The tylenchid-complex was analysed in every sample and the mean moisture content of the soil sample taken to a depth of 8 inches was similarly determined. The composition of the soil tylenchid-complex is tabulated below:—

Composition of the Soil Tylenchid-complex

Meloidogyne hapla	92
Pratylenchus n. sp.	85
Aphelenchoides spp.	76
Aphelenchus sp.	96
Tylenchorhynchus sp.	13
Tylenchus sp.	29
Ditylenchus sp.	13
Total Samples Analysed ..	220

166. The results in this table are the frequencies of occurrence of the tylenchid species expressed as percentages of the total analyses. The complex is therefore composed largely of the first four components in the table and the complex would appear to be relatively stable in composition, although the populations of the component species is very variable. *Meloidogyne hapla* and

Pratylenchus n.sp. were the principal nematode pests of this pyrethrum field. The former was responsible for Root-knot disease, the latter for Root-rot disease. *Aphelenchoides* spp. and *Aphelenchus* sp. were almost invariably present although in rather small numbers.

167. The population fluctuations of the nematode fauna of the soil and the roots of the crop were particularly interesting. It was found that the changes in the mean population levels in the soil of *Meloidogyne hapla, Pratylenchus* n.sp. and the total nematode fauna were inversely related to (*a*) the total rainfall between the successive sampling dates and (*b*) the mean moisture level of the samples at the given sampling date. Thus the highest soil moisture level (39.8 per cent of the wet weight of soil) was associated with the lowest nematode populations of the soil, and conversely the lowest mean soil moisture level (29.8 per cent) was associated with the highest nematode populations of the soil. These results proved to be of statistical significance, with a high significance for the example quoted.

168. There was a rise in the mean Root-knot index over the year, the onset and duration of the long rains being associated with a steady rise in the index, the succeeding drier period being associated with a slight fall of the index from the maximum reached by the end of the long rains. The mean Root-rot index was found not to follow quite the same trend, its maximum being achieved earlier in the rains. Both nematode diseases were, however, more prevalent at the end of the year's observations than at their beginning.

169. There was not a direct relationship between the root-populations of a given parasitic species and its soil population. This is to be expected since the two populations are under the influence of different sets of environmental factors.

Taxonomic Studies of the Genera Meloidogyne, Helicotylenchus, Scutellonema, Gottholdsteineria *and* Rotylenchus

170. *Meloidogyne* Goeldi. Some 450 populations of the nematode genus *Meloidogyne* Goeldi from East African soils have been analysed on the basis of the posterior cuticular pattern of the female nematodes. To date the following species have been encountered, but owing to the unsatisfactory state of the taxonomy

of this genus, which it is hoped to revise in the near future, species considered to be inadequately defined are given in inverted commas:—

M. "javanica"; M. "hapla"; M. "incognita"; M. "incognita var. acrita"; ?M. arenaria"; ?M. "acronea"; M. africana Whitehead (in press). In addition a number of new or apparently new species are known and will be described in due course. Many populations are extremely difficult to ascribe dogmatically to known species, although resembling them to a certain degree. It is clear that certain species, if not all of them, are a complex of races.

171. *Helicotylenchus* Steiner. There are numerous species of this genus in East African soils which are apparently ectoparasites of the root system of plants. Without careful morphological analysis they could easily be identified as a single species. It is found that number of head annules, tail shape and other characters are relatively constant for a given population and differ from those of other species when subjected to close examination. In this way *Helicotylenchus erythrinae* (Zimmermann, 1904) Andrassy, 1958, as described by T. Goodey (1940), was found to be composed of distinct populations from three different geographical areas. It is also clear that the genus *Helicotylenchus* Steiner, 1945, has no real validity, since its erection was based on a wrong assumption.

172. *Scutellonema* Andrassy, *Gottholdsteineria* Andrassy and *Rotylenchus* Filipjev. The genera *Scutellonema* and *Gottoldsteineria* are common in East African soils and their morphology has been studied in some detail. It is clear that the number of head annules, the nature of the lateral fields, tail shape and size, position and nature of the phasmids and other characters, particularly at the anterior end of the nematodes are of considerable importance in the separation of the species. The distinctions between the three genera above are not at all clear and it is felt that it may be desirable to include them with *Helicotylenchus* Steiner under the older generic name *Rotylenchus* Filipjev, 1934.

INTRODUCTION OF PLANTS FROM OVERSEAS

H. H. Storey and F. M. L. Sheffield

173. During the year the Standing Technical Committee held one meeting and its Subcommittee two. Much of its business

has concerned relations with the I.A.P.S.C.; and a number of proposals have been submitted to this body for consideration.

174. In September, 1958, the Inter-African Phytosanitary Commission agreed on recommendations to be made to governments regarding restrictions to be imposed when certain propagating materials are imported from outside Africa South of the Sahara. The recommendations necessitated a revision of the Schedule of Plants coming into East African Territories. This Schedule comprises recommendations made by the Standing Technical Committee to the East African Territorial Governments: the restrictions proposed must be at least as severe as those suggested by I.A.P.S.C., but, being concerned also with plant movement within Africa South of the Sahara, it is a much more comprehensive document. The revision brought to light certain anomalies and inconsistancies in our then existing Schedule that it was necessary to correct. We decided at the same time to include some general instructions and to define for each species listed what certification is required. F. M. L. Sheffield and P. J. Dickinson of the East African Plant Quarantine Station undertook to write the first draft of the new Schedule. This was submitted to the Subcommittee of the Standing Technical Committee who amended it for discussion at a meeting of the full committee. The new Schedule was prepared and issued from E.A.A.F.R.O. in August in the form of a card index. Ninety copies have been sent out to officers in the East African territories concerned with the formulation or operation of the regulations and also to certain officers concerned with the formulation of plant import control regulations in other countries. A further revision of certain sections will be necessary almost immediately, to include internationally agreed restrictions altered by the I.A.P.S.C. in October, 1959, and to bring up to date in the light of new knowledge some other restrictions.

175. E.A.A.F.R.O. continued to import all new varieties of sugar cane required by growers in East Africa and also to supervise all other introductions made through East African Plant Quarantine Station. Most of the supervision was done by F. M. L. Sheffield who called in other specialist officers when their advice was needed. A considerable number of diseased plants were intercepted during the year. (c.f. p. 86.)

ANIMAL HUSBANDRY DIVISION

176. *Staff Changes.* Dr. D. W. Duthie, Biochemist, retired after long service in East Africa on 18th June, 1959. Mrs. A. E. Bazin joined the staff to take charge of the routine biochemical laboratory on 13th April, 1959. Dr. H. G. Livingston transferred from the Kenya Agricultural Department on 1st October to take the post of Animal Nutritionist in the Division. At the same time, Mr. K. R. Southon transferred from the Kenya Veterinary Department.

EXPERIMENTAL FARM

A. F. Dent and Mayda Kapitapa

177. *Buildings.* A series of new storage bins for mixed feed has been completed at the piggery and machinery for milling, mixing and pelleting feeds has been installed. Water has also been laid on to the pig paddocks and individual drinking bowls installed in the new deep litter piggery and the farrowing pens.

The deep litter piggery has been completed and individual feeding facilities are being installed.

A new building that will house 52 individually-fed beef animals is nearing completion and the cattle yards are being re-organized and rebuilt.

178. *Pastures.* A programme to replant the whole of the grassland area of the farm with the indigenous star grass (*Cynodon dactylon*) commenced this year. It was intended to replant 65 acres during the year but this target was not attained owing to various factors, one of which was the drought, for the normal rainfall up to the end of October is 31 inches, whereas this year it was only 18.6 inches.

179. In spite of setbacks, 16 acres were planted to star grass and oversown with oats. Unfortunately this crop was almost a complete failure, due to partial failure of the long rains. Star grass alone was planted on 28 acres during the long rains and this area was then divided into *shambas* in order that African employees could keep the land clean, at the same time taking off a bean crop, while the grass became established. A further 19 acres were felled, divided into *shambas* as before and will be planted to star grass during the long rains of 1960. The remaining two acres were planted with *Medicago denticulata* but again due to poor rainfall no hay was harvested.

180. Despite the poor long rains, the star grass planted during the year has survived the drought and, with the exceptionally heavy short rains (over 10 inches during November and the beginning of December) has grown very well, there being no failures.

181. Three fields of approximately 47 acres, which were planted to star grass during 1958, were harvested for hay and gave an average yield of 1.6 tons per acre. In this connexion, mention should be made of the very ready help given by Messrs. Farm Machinery (Distributors) Ltd., who came to our assistance by supplying a baler when our own machine broke down.

182. *Crops*:—

(*a*) *Edible Cannas.* These were planted on the agricultural rotation experimental plots during the long rains and stood up to the drought exceptionally well. They have not yet been harvested.

(*b*) *Oats.* As mentioned previously, these were almost a complete failure due to the drought.

(*c*) *Grass and Legume Plots.* A number of species new to Muguga were planted out during the year. The grass green panic (*Panicum maximum* var. *trichoglume*) and the legume *Desmodium uncinatum* appear to be promising.

183. *Livestock*:—

(*a*) *Beef Cattle.* The Boran steer herd is now mature and has been used as experimental material by the Meat Unit.

(*b*) *Identical Twin Herd.* Identical twins have been collected throughout the year at a very satisfactory rate. There are now 32 sets of grade and zebu type cattle in the herd.

(*c*) *Sheep.* All the sheep have now been disposed of with the exception of one animal. This animal has recently been used for a feeding experiment in collaboration with Dr. Dougall of the Grassland Research Station at Kitale.

(*d*) *Pigs.* Despite the unsatisfactory position of the pig industry during the latter part of 1958 and the beginning of 1959, the pig herd has been increased and is to be increased further.

The breeding herd now consists of 30 sows and gilts. This is not yet up to our target figure which is 40 Large White and ten Landrace sows and gilts. This will take some time to attain due to the heavy culling programme. The herd is now composed of almost all pedigree stock and there are altogether eight strains of Large Whites. Although the pig herd is run primarily to provide experi-

mental animals for the pig experimental programme a breeding programme for the herd has been evolved and Large White boars and gilts will be first, performance and then progeny tested. Landrace breeding stock can only be performance tested, as there will be insufficient numbers to progeny test.

The champion Landrace boar at the 1959 Royal Agricultural Show was bred by this Organization, although not exhibited by ourselves. With the purchase of two Landrace boars during the year, we now have in the pig herd almost all the Landrace strains that are to be found in East Africa. A further two Wessex gilts were purchased and together with the original one given to us, have been used in a small scale cross-breeding experiment. It is not intended to breed Wessex pigs.

We have been called in to advise on various problems arising in the industry from time to time. The formula for the present Pig Industry Board protein and mineral supplement was worked out by E.A.A.F.R.O. and also a trace element premix, which is now being marketed by a local branch of a world-wide concern.

Finally in addition to our own experimental work a number of experiments are being undertaken in collaboration with the Territorial Departments and the quality of all pig carcasses from these experiments are assessed by E.A.A.F.R.O. by kind permission of Uplands Bacon Factory.

184. *General.* No outbreaks of disease have occurred on the farm this year although the adjoining reserve had been almost continuously in quarantine for foot-and-mouth.

BEEF CATTLE UNIT

W. J. A. Payne, H. G. Livingston, H. P. Ledger, K. R. Southon and Nelson Mwangi

185. The study on the relative efficiency of the Boran and the Shorthorn Zebu in converting feed into beef has not yet commenced. The building equipped for individual feeding of cattle is almost complete but as yet quarantine restrictions at Isiolo in Kenya, prevent the importation of the Boran cattle to Muguga.

186. Dr. Livingston is preparing a bibliography on intake studies and is planning his equipment needs. He will start the intake studies when he returns from leave in the autumn of 1960.

187. A co-operative trial with the Department of Veterinary Services, Tanganyika, to be conducted at the Northern Province Stock Farm, Ngare Nairobi, has been planned. It will be a study of the water requirements and productivity of indigenous cattle when subjected to the stress of infrequent watering and long daily treks.

188. The livestock for this experiment, ten sets of zebu-type identical twins, have been selected from the identical twin herd at Muguga.

SHEEP AND GOAT UNIT

W. J. A. Payne and H. G. Livingston

189. Small scale preliminary studies undertaken in co-operation with the Kenya Agricultural Department at Eldoret Agricultural Station have shown that the respiration rates of temperate-type sheep are unusually high. This may account in part for the unthriftiness of some temperate-type sheep at the higher altitudes.

PIG UNIT

W. J. A. Payne, A. F. Dent and James G. Rimomo

190. A loosely organized but co-ordinated pig research programme is being conducted by the Kitale, Eldoret and Ol Joro Orok stations of the Kenya Agricultural Department, the Naivasha station of the Kenya Veterinary Department and this Unit. It is concerned in the first place with evaluating the Pig Industry Board protein and mineral supplement, the type of cereal mixtures that it can be used with, how restricted such rations have to be in order to produce AA+ carcasses, and in what quantities it will replace skim milk as a protein supplement on farms where the supply of skim is intermittent.

191. At Muguga, management nutritional and a small scale breeding experiment are being conducted. The study on the effect of farrowing equipment and the microclimate in the farrowing pen on the incidence of piglet mortality continues. In Table 1 is shown the effect of the four treatments on mortality due to "laying over", during 1958. There was no mortality in those litters that were farrowed in the heated round houses. Results during 1959 confirm that "laying over" mortality is very low when this type of farrowing system is used. This experiment will be continued until mid-1960.

TABLE 1

The Effect of Farrowing Treatment on the Incidence of Piglet Mortality Due to "Laying Over"

	Round House		*Conventional House*	
	Heat	*No Heat*	*Heat*	*No Heat*
No. piglets	29	24	79	33
No. piglets "laid on"	0	5	8	6
% mortality due to "laying over" ...	0	20.8	10.1	18.2

192. In another study piglets are still being raised artificially once they have received colostrum from their dam. Mortality amongst these piglets has been low but weaning weights have not generally been satisfactory. This study continues.

193. Four major nutritional studies have been operational during 1959. The first is concerned with the effect of environmental temperature on the nutritional demand for iron and the incidence and severity of anaemia in piglets. Ten sows and 180 piglets are being used in this experiment. Each sow is farrowed twice, once in heated and once in cold farrowing accommodation. The litter is reduced to nine piglets, surplus pigs being placed on the artificial feeding régime. The nine piglets are grouped according to sex and weights at birth and one from each group is placed on one of three treatments, i.e. injected iron, oral iron, or no iron. Results to date suggest that the piglets receiving injected iron demonstrate the least symptoms of iron anaemia, and that in all groups the haemoglobin content of the blood is higher in those piglets accommodated in heated rather than in unheated farrowing pens.

194. A second investigation is concerned with the effect of restricted feeding, the feeding of high fibre feeds and the use of synthetic oestrogens on the carcass quality of bacon pigs. It is realized that individual feeding increases managerial responsibility and cost and a method is sought of producing high quality bacon carcasses while feeding pigs *ad lib*. It is considered that the use of synthetic oestrogens in an *ad lib* ration may delay maturity in the pig and therefore the deposition of fat thus improving the quality of the carcass. This experiment continues.

195. The third investigation is a study of four different protein and mineral supplements to high maize content rations. One of the supplements under study is the Pig Industry Board protein and mineral supplement, the other three are very similar mixes but

contain different amounts of cottonseed meal. As cottonseed meal is the cheapest form of protein obtainable in East Africa it is thought that the possibility of including a higher percentage of cottonseed meal in the P.I.B. protein and mineral supplement should be studied.

196. Finally we are investigating the effect of varying the percentage of individual amino-acids in a protein supplement, on productivity and carcass characteristics. During 1959 the amino-acids tryptophan and lysine have been under trial. None of these experiments have yet been completed.

197. The small scale breeding experiment is a preliminary attempt to evaluate a triple cross for pork or bacon production. In the first stage Large White boars are crossed with Wessex sows. In the second stage Landrace boars are crossed with the first cross Large White × Wessex sows. At all times the value of the crossbreds can be compared with contemporary purebred Large Whites. It is hoped to combine the desirable features of all three breeds, that is the prolificacy of the Large White, the mothering and milking ability of the Wessex and the carcass quality of the Landrace.

MEAT UNIT

H. P. Ledger and Watson N. O. Gichuru

198. The first half of the year was spent on vacation leave in the U.K. when research stations were visited and discussions held with those working on carcass evaluation and allied subjects. I am very appreciative of the most helpful and cordial reception I received at all the places visited.

199. These discussions did not reveal any need to alter the system of carcass analysis used at Muguga but did emphasize the necessity for finding a reliable and simple method for estimating the total fat *in vivo* and in the carcass. Returning to Muguga, routine dissections were continued and by the end of the year a total of 74 carcasses had been analysed comprising the following: —

60 Boran zebu steers.

11 Boran zebu cows.

2 Grade cows.

1 Grade steer.

200. Requests from Territorial Departments continue to be met; amongst which are the "sample joint" trial in conjunction with Dr. Hutchinson of the Tanganyika Veterinary Department, and the development of a standard analysis technique for sheep and goats for the same department. Routine analyses of carcasses are also being carried out for the Kenya Veterinary Department. At the request of the Uganda Veterinary Department, a member of their staff spent two weeks in the laboratory familiarizing himself with carcass analysis techniques.

201. The second half of the year was mainly spent in accumulating data for future analyses and such progress as has been made is reported below under the various experimental headings. In most cases the titles are self explanatory:—

(*a*) *A Comparison of the Analyses of Boran* (*Bos Indicus*) *Carcasses with those of Temperate-type* (*Bos Taurus*) *Cattle in the U.K.*

A comparison of the figures obtained for the amount of subcutaneous and intermuscular fat for the two species indicates a marked difference in the methods which each use to deposit fat during fattening. The Boran puts on more intermuscular and less subcutaneous fat than does the temperate animal. It is suggested that this fact, may, in part, explain the differences in heat tolerance exhibited by the two species.

(*b*) *The Relationship Between the Commercial Grading, Analyses and Measurements of Boran Carcasses*

This results automatically from the fact that all carcasses are given a commercial grading by Kenya Veterinary Department graders. An assessment has been delayed owing to the fact that the grading regulations were altered during the year. This meant that no valid comparison could be made between carcasses graded under the old and new system. There should be a sufficient number of carcasses analysed to enable this to be done early in 1960.

(*c*) *To Investigate the Growth Rate, Commercial Grading, Carcass Composition and Cartilage Calcification of a Mob of Identical Managed Range Fed Boran Steers Slaughtered at* 18 *Months,* $2\frac{1}{2}$, 3, $3\frac{1}{2}$ *and* 4 *Years Old*

This is a long-term project and the first group of ten 18-months-old steers were slaughtered and analysed during November.

(d) A Comparison of the Carcass Analyses of Zebu Steers of Known Age and Growth Rate Slaughtered at a Specified Live Weight of 1,176 *lb. or Four Years of Age, Whichever is Reached First*

These are analyses done for, and in collaboration with, Mr. Lampkin, the geneticist in charge of the East African Veterinary Research Organization's Boran herd at Muguga. This again is a long-term trial.

(e) To Investigate the Use of Sample Joints as Indicators of Carcass Composition

The preliminary stage of this work was reported on in last year's annual report. A further 33 tenth rib analyses have been done and have been forwarded for statistical analysis. The results will be submitted for publication in an appropriate journal during 1960.

(f) Investigations of Physical Methods of Measuring Fatness in the Carcass and in Vivo

No progress has been made owing to lack of staff.

(g) Correlation of Linear Measurements of Carcasses and the Live Animals with the Fat Content of the Carcass

This awaits the completion of a sufficient number of analyses covering a wide enough range of fatness to make a study of the possible correlations worth while.

BIOCHEMICAL UNIT

Dr. D. W. Duthie and Mrs. A. E. Bazin

202. A study was begun of the gossypol content of East African cottonseed meals by Dr. D. W. Duthie before he retired. Methods for the estimation of both free and total gossypol were evaluated but the investigation has now been suspended until a biochemist has been appointed to succeed Dr. Duthie.

203. In the routine biochemical laboratory chemical estimations of the hardness of fat samples from all experimental pigs have continued. During 1959 the "iodine value" of 355 samples has been determined. In addition small experiments have been conducted for the Uplands Bacon Factory. In the first experiment the subjective test of the grader for the quality of the fat has been checked against the objective chemical "iodine value". It was

found that there was a significant correlation between the results from the two tests, and that in general the grader was able to pick out the hard from the softer fats but that he was not completely accurate in his placings. In the second experiment the effect of a "singeing" machine on the quality of the fat was tested. It was found that the machine did not effect the quality of the fat in any way.

204. Work has also continued for the Meat Unit, minced lean and fat meats being analysed for moisture and fat content. A large number of pasture grass and legume samples have also been analysed for moisture and crude protein content.

FORESTRY

SILVICULTURE RESEARCH

A. L. Griffith and P. Howland

205. Once again work has in general continued on the long-term lines laid down for us by the E.A. Advisory Council in 1952. This general programme was intended to last for at least ten years. The main emphasis has been on the Information Section, softwood problems, and the development of Muguga Estate for experimental purposes.

206. The Forester was on long leave for the first six months of the year and during his leave visited the Imperial Forestry Institute, Oxford, the Forestry Commission Research Centre, Alice Holt, a number of forests in the United Kingdom, the Black Forest of south-west Germany, the Swiss Research Department in Zürich, the School of Forestry in Florence, F.A.O., and the Italian Research Centre in Rome.

207. The Silviculturist was on leave in July and visited the dry forest areas of Greece, Turkey, the Aegean Islands, and also Eritrea.

208. In November, 1959, the Silviculturist attended the C.C.T.A./C.S.A. meeting of Specialists on the Woodlands of Africa South of the Sahara. There were 45 delegates from 15 countries and of four nationalities. This is the first time that the dry forests have been discussed on an Inter-African basis. The meeting was held at Ndola in Northern Rhodesia's Copper Belt, which is about the centre of the 2 to 3 million square miles of the Central African "miombo" woodland. The Silviculturist also attended the E.A. Timber Advisory Board meeting at Entebbe.

209. In November also we held our Seventh Forestry Course at Muguga. It was attended by 19 delegates from four countries. Among the delegates were four African foresters from Uganda and one Somali. We have now had 116 Assistant Conservators and Foresters on the courses. In early May, 85 African Boy Scouts from six troops camped in the E.A.A.F.R.O. African School for a weekend and were taught how to plant trees. In October, the Forest Ranger Class of the Tengeru Natural Resources School (Tanganyika) visited us for a week.

210. The main item of news of the year 1959 is that the climatic conditions have been the hardest for planting since we started at Muguga in 1950. The long rains of March, April and May only produced a little over 50 per cent of their normal. We

were not able to plant until early May, and then had to plant on what experiments had shown to be the absolute "safe" minimum, 1.5 inches of rainfall build-up and a 6-inch depth of soil wetting. A few days after planting the rains ceased, and we had 72 consecutive days of drought and in the five months after planting we only had 2.45 inches of rain. Under these conditions, we planted 52 new plots in the Arboretum, 12 Short-term Experiments, and 71 acres of eucalypts. This planting has been extremely successful in spite of the conditions, and in the Arboretum only two plots have failed. One of these was due to unsuitable nursery stock that we had to get from outside, and which had not been root pruned.

211. This year's work has completely proved the validity of our theories and experimental evidence from short-term experiments of the past seven years on soil moisture at planting time, the date and conditions for "safe" planting, plant exposure, plant storage and depth of planting.

212. When reading this report it must be realized that our long rains occur in March, April and May, and hence our nursery experiments, our short-term experiments and all our routine planting is done in this period. These experiments are measured and assessed in the following March, and hence most of the results in this report are at least nine months out of date. The experiments of 1959 will not be measured until March 1960, and hence results will appear in next year's report. In this report we can only give their indications from the aspect of their survival percentage after six months.

213. An interesting experiment of the year is an attempt to reproduce an Australian dry forest. This consists of a eucalypt (*Euc. crebra*), a casuarina (*Cas. leuhmannii*) and two species of *Callitris*. The experiment has started off very well. In Australia the type occurs in the north-west of New South Wales and the south-west of Queensland, in a rainfall of some 5 to 15 inches. It might well succeed in some of our lower elevation, dry, eroded and termite-infested areas.

214. The headings of the report that follows are those of the long-range programme:—

I. INFORMATION SERVICES

215. The Forest Bureau was maintained and expanded and now contains 1,979 Specific Ledger Files and 897 General Ledger Files. The Service of issuing periodically lists of highlights of information ledgered has been continued and has proved very

popular. Many enquiries were received and answered and we have been happy to welcome many visitors, official and unofficial from all walks of life and business who care to see for themselves the various species of trees and hedges actually growing.

II. STANDARDIZATION OF RESEARCH PROCEDURE

216. Several modifications of our research procedure were adopted.

III. RESEARCH ON SOFTWOODS

217. In the following report on seed, seed orchards and nursery problems, Mr. W. B. May (Horticulturist) and Mr. P. Dickinson (Plant Quarantine) have both collaborated.

A. Seed Problems

218. *Cotyledon Numbers.* The long-term experiments planted out in 1954 (E.P.4a) and 1955 (E.P.4b) with *C. lusitanica* of two, three and four cotyledons and in 1954 (E.P.7) with *P. patula* of four to nine cotyledons, *Pinus caribaea* (now *P. elliotti*) of four to nine cotyledons, *P. radiata* of seven to nine cotyledons and *C. lusitanica* of two to four cotyledons were continued. In 1959, after four and five years respectively, no significant differences in height growth or survival percentage have yet resulted. It appears unlikely that they will appear.

219. *Seed Orchards.* Work on the technique of grafting under field conditions (Mr. May) and under glass-house quarantine conditions (Mr. Dickinson) continued. We now get a very high percentage of "takes" even though we have no dormant season. Most of the work is with *P. radiata* (which is a late and shy seeder) and with locally grown *P. patula* (an early and profuse seeder). Timber tests on strength, fibre length, etc., are urgently needed so that we will be able to identify an "elite" tree. At present we are working on what we call "Plus Trees" decided by their external physical characteristics.

B. Nursery Problems

(*Experiments started in April,* 1958, *and concluded in March,* 1959)

220. Experimental work in the nursery at Muguga has continued. This is long-term work, for in our very variable climate many years of repetition are required to cover the climatic range. Weather variations have been very great, and in the past seven

years since we started this work we have had one nearly normal year, two year's above normal, and four years below normal for rainfall. This present year (1959) has again been different as the long rains in March, April and May were very much below normal, and the short rains in November and December, so far, are very much above normal.

221. It should be noted that all our planting is done in the long rains, and no planting is normally possible in the short rains.

222. *Fertilizers.* The experiments described in previous years' reports were repeated in 1958 (measured in 1959). They were with *P. patula* seedlings and serve as the general control of our minimum fertilizer experiments. We now have seven years' repetitions. N.P. and K. were applied in all combinations and at three rates which were:—

Fertilizer rate 0.		No fertilizer.
Fertilizer rate 5.	N.	Sulphate of ammonia (20 per cent N) 540 lb. per acre or 8 gm. per box.
	P.	Double superphosphate of lime (39 per cent soluble P_2O_5) 540 lb. per acre or 8 gm. per box.
	K.	Sulphate of potash (52 per cent K_2O) 270 lb. per acre or 4 gm. per box.
Fertilizer rate 10.		Twice the above quantities.

223. These rates are called "5" and "10" as they are 5 and 10 times the rates which are normally used in agriculture in the United Kingdom. The experiments confirmed previous indications, the chief of which is that there is little difference in response between the "5" and "10" rates of application and hence the latter rate is unnecessarily high. In consequence, in 1955, experiments were started to try and find out *minimum* fertilizer requirements.

224. *Minimum Fertilizer Requirements.* In view of the above, experiments were started in 1955 to measure the response of seedlings to lower fertilizer rates. Three years experiments with two pine species failed to show any appreciable response to fertilizer applications of less than rate "5" described above.

225. The experiments were continued in 1958 but the soil mixtures used were (*a*) Muguga Standard Mixture (without basic N.P.K.) and (*b*) Muguga Standard Mixture (without basic N.P.K.

and without horse manure). Two species were used, *P. radiata* and *P. patula,* but we are still without any indication of what the minimum fertilizer requirements are at Muguga.

226. *Effect of Restricting Evaporation in Transplant Boxes.* This subject was repeated for the fourth year. Treatments were (*a*) boxes sunk to ground level, (*b*) boxes placed normally on a gravel base and (*c*) boxes placed normally on a gravel base but mulched with chopped straw after the short rains, i.e. for the dry season of January, February and March. The species used were *P. patula* and *P. radiata.*

227. The results confirmed those of previous years that the sunk boxes and the mulch definitely increase the height growth of both species and that *P. patula* is far the more sensitive species, but though much more repetition is required it appears unnecessary to sink boxes if one is prepared to water adequately. If one is not prepared to water adequately, or if one is unable to water adequately, there is no justification for establishing a nursery!

228. *Transplant Spacing in Beds.* The experiment was repeated for the fourth year in which the development of plants which were pricked out at two by two, three by three, and four by four inches espacement was observed. Wider spacing than four by four inches is not possible as it is outside the scope of practical economics. In general, so far, observation has shown that there is little difference in height growth and survival percentage between the treatments. However, the wider the spacing, the better the development and sturdiness of the plants.

C. Short-term Planting-out Problems

229. These short-term experiments were started in 1952 to compare different establishment techniques. So far, 108 experiments have been completed and 12 have been started in the long rains of 1959. The results as summarized are often only tentative as the experiments must be repeated over a number of years in order to cover the climatic range.

230. A summary of the first five years' results which was presented to the Seventh British Commonwealth Conference of 1957 was given in least year's report and is therefore not repeated.

231. *Different Dates of Planting.* We now have six years' experimental evidence of weekly planting from the middle of March to the end of May each year for *P. patula, P. radiata* and *C. lusitanica.* With all three species height growth and survival

percentage drop markedly with late planting. In these experiments at each date of planting an estimate of depth of soil wetting is made and from the rainfall records the rainfall "build-up" is calculated daily allowing for the daily evaporation.

232. The criteria for the earliest safe date for planting at Muguga have been completely confirmed in 1959 which, as stated in paragraph 209 above, has been the poorest and most difficult climatically since we started in 1950. These criteria were stated in last year's report and are therefore not repeated.

233. *Comparison of Different Depths of Planting.* Ten experiments with *P. patula, P. radiata* and *P. leiophylla* have been done in the past five years in which plants were planted (*a*) at the collar, (*b*) two inches above the collar and (*c*) four inches above the collar. The 1958 experiments confirmed previous indications that deep planting does not result in any deleterious effects but causes a stimulation of height growth of some 10 to 30 per cent depending on the climate of the year. This also confirms work in the U.S.A. on deep-planting the Southern Pines.

234. *Comparison of Bare-rooted and Ball-planted Transplants.* A number of experiments have been done over the past five years with *P. patula* and *P. radiata.* Indications are that in Muguga conditions it is well worth while to take the extra trouble and small extra expense and use ball-planted plants. The small gain in cost is not worth the risk of using bare-rooted plants except under the most favourable conditions. This has been completely demonstrated by the current experiments in the abnormally hard climatic conditions of 1959 when comparatively few bare-rooted plants survived the five months' drought which followed planting.

235. It should be realized that at the time of starting the nursery stock it is not possible to estimate whether the following long rains will be good, normal, or poor.

236. *Effect of Storage of Naked Rooted Stock.* A further experiment was done with *P. patula.* The stock was lifted and all soil shaken off the roots. It was then bundled in wet gunny, taken to the planting site and one set planted immediately. The second and third sets were thoroughly wetted and left for 24 and 48 hours respectively. The indications of five years' work are that *P. patula* is more sensitive than *P. radiata,* but both species can be stored thus for 48 hours if necessary. The practise is, however, to be deprecated and planting should be done as soon after lifting as possible. This has been completely vindicated under the hard climatic conditions of 1959.

237. *Effect of Exposure of Naked Rooted Stock.* Parallel to the above experiment, naked rooted stock of *P. patula* was (*a*) planted at once, (*b*) exposed for 15 minutes, (*c*) exposed for 30 minutes and (*d*) to (*f*) exposed for one hour, three hours and six hours. Four years' experiments have shown that exposure for even as short a period as 15 minutes can be fatal. It is thus demonstrated that a lot of plantation failures are probably due to the fact that the plants were "dead before they were planted".

238. *Comparison of the Best Plants with the "Runts" from a Nursery Bed.* A further experiment in this subject was done with *P. patula*. Out of about 8,000 plants, the 100 best and the 100 poorest were selected and planted. The experiment confirmed four years' indications that there is little difference in survival percentage and actual height increment between the two classes in the first year. The difference in the sturdiness of the best plants and their race against the weeds is very marked. An increment of 20 inches on to a two-foot plant has a very different effect from an increment of 20 inches on to a one-foot plant.

239. *Planting Stock Raised by Different Box and Bed Techniques.* Two further experiments were done during the year in which the best bed plants were compared with the best box plants for both *P. patula* and *P. radiata*. The results of five years' experiments show that under Muguga conditions it is not worth while to use the cheaper bed method. The use of boxes is more expensive but it is a worthwhile insurance against failure in adverse climatic conditions. This has been conclusively demonstrated in 1959.

240. *Cover Crops in Young Cypress Plantations.* Observation of the experiment, started in 1954 (E.P.5), was continued. The cover crops were introduced into a one-year-old cypress plantation in an endeavour to keep out the grass which often comes in as a result of heavy thinning and pruning which is necessary to produce clean timber. The two cover crops which have been most successful are *Tephrosia vogelli,* which is, however, rather short lived and is now about at its end and *Prunus salasii,* which each year gets better and better. *Centrosema pubescens* and *Pueraria javanica* proved complete failures. In some of the control plots *Neoboutonia macrocalyx* has come in naturally and appears to be a very useful natural cover crop. It is, however, quite impossible to predict whether or not it will come into any particular area.

241. *Effects of Shamba Crops and Cultivation.* An experiment was started in 1955 (E.P.11) in conjunction with the soil physics division to study the effects of *shamba* crops on the

height growth and survival percentage of the forest crop. The *shamba* crops were (*a*) maize, (*b*) beans and (*c*) maize and beans together. The general result at the end of the first year was that the *shamba* crops reduced the height growth of the forest crop by some 10 to 15 per cent in height, but had little or no effect on the survival percentage.

242. After four years, *shamba* crops are, of course, no longer possible but the *shamba'd* plots are still some 5 to 7 per cent behind the non-*shamba'd* plots in height growth.

D. Long-termed Problems

243. We now have eight Sample Plots and four more will be laid out shortly. These 12 plots will cover nine species.

244. The two experiments started last year in three-year-old crops to test the effect on the height and diameter growth of *Pinus radiata* (E.P.17) and *Cupressus benthamii* (E.P.20) of annual pruning to one-half tree height, two-thirds tree height and of three-quarters tree height up to 30 feet, have shown that in the first year after treatment the increment in height and diameter growth was retarded by some 15 to 30 per cent depending on the intensity of the pruning.

245. In collaboration with the E.A. Herbarium, a start has been made in the preparation of a check list of the species in the area of relict natural forest in the estate. This natural forest area is the control for all local experiments involving the change of land use and particularly for the short-term cropping experiments.

E. Species Trials (Mainly Exotic)

246. *Arboretum.* Fifty-two new plots were planted during the year. These were chiefly of eucalypts, casuarinas and *Callitris,* mainly from the drier areas of Australia. We now have 214 plots and 163 species of which 51 are eucalypts (76 plots), 24 pines (36 plots), 15 cypress (17 plots), 10 acacias (14 plots), and 5 *Callitris* (10 plots).

247. Some species have shown remarkable growth. The height given is the "top height", i.e. the mean height of the best 100 trees per acre. The plots are approximately one-tenth of an acre in area and the top height measured in each plot is thus the mean height of the ten tallest trees. The diameter given is the mean d.b.h. of all the trees in the plot.

Cupressus benthami
36 feet and 5.4 inches diameter in seven years.
Pinus radiata
30 feet and 4.6 inches diameter in seven years.
Pinus patula
28 feet and 4.5 inches diameter in seven years.
Pinus canariensis
25 feet and 4.2 inches diameter in seven years.
Pinus taeda
26 feet and 4.7 inches diameter in six years.
Cupressus lindleyi
30 feet and 5.3 inches diameter in six years.
Callitris calcarata
21 feet and 3.3 inches diameter in five years.
Among the eucalypts the following are worthy of note:—
Eucalyptus saligna (Australia)
63 feet and 6.9 inches diameter in six years.
E. saligna (Kenya)
67 feet and 6.9 inches diameter in seven years.
E. botryoides
52 feet and 6.5 inches diameter in six years.
E. macarthuri (a wind-break species)
47 feet and 5.6 inches diameter in six years.
E. grandis
63 feet and 6.6 inches diameter in five years.
E. regnans
60 feet and 6.4 inches diameter in five years.
E. fastigata
45 feet and 6.1 inches in diameter in five years.
E. globulus
45 feet and 5.1 inches in diameter in four years.
E. cloeziana (a heavy purpose timber)
42 feet and 4.7 inches diameter in four years.

248. *Live Hedges.* These are all doing well except *Dodonea viscosa* which died out to about 50 per cent during the 1959 drought.

249. *International Eucalypt Trial.* This trial, under the aegis of I.U.F.R.O., continues to grow well. It consists of five replications of 12 species or strains and has been repeated in 18 countries.

IV. ENUMERATIONS AND V. REGENERATION OF HARDWOODS

250. Further work was done in the territories. E.A.A.F.R.O.'s contribution was purely advisory.

VI. SHORT-TERM TREE CROPPING

251. The replicated ten-acre experiment to test the relative fuel yields of three eucalypts is now nearly five years old and will be felled and measured for the first time after another two or three months. The species are *E. grandis* of Australian origin, *E. saligna* of Australian origin and *E. saligna* of local origin (known to be a hybrid of *E. saligna* and *E. grandis*).

252. An experiment (E.P.18) to test the effect on stool mortality of felling at ground level by axe and by saw a six-year-old crop of *E. saligna* showed that six months after felling, the axe felling had regenerated by 94 per cent and the saw felling by 100 per cent. It must further be remembered that billeting by the axe instead of by the saw wastes some 10 to 20 per cent of the fuel.

253. During the year, the density and calorific values of our local fuels were measured. Results are:—

Wattle (*A. mollissima*/*A. decurrens* local hybrid)
Eight years old.
Density: 53 lb. per cu. ft.
Calorific value: 4,159 cals. per gm.

Gum (*E. saligna*/*E. grandis* local hybrid)
Six years old.
Density: 47 lb. per cu. ft.
Calorific value: 4,153 cals. per gm.

Pine (*P. radiata* thinnings (South Africa origin)
Seven years old.
Density: 38 lb. per cu. ft.
Calorific value: 4,040 cals. per gm.

Cypress (*C. lusitanica* thinnings) (Kenya origin)
Seven years old.
Density: 30 lb. per cu. ft.
Calorific value: 4,214 cals. per gm.

254. In a few years we will have accurate yield figures and will then know how many calories per acre per annum we are growing.

VII. YIELD TABLES FOR IMPORTANT SPECIES

255. No further work was done as no further data has come in from the Territories. A technical note was written on the "stock mapping to quality class of an even aged plantation".

VIII. MUGUGA (*E.A.A.F.R.O.*) ESTATE

256. Maintenance of the estate continued and the work chiefly consisted of the conversion of wattle to softwoods for experimental purposes, species trials, and to eucalypts to provide fuel and poles for the station. Fifty-two new arboretum plots, 12 short-term experiments and 71 acres of eucalypts were planted. We have now nearly finished the conversion of the estate and next year's planting will largely consist of tidying up.

FOREST ENTOMOLOGY

T. Jones and W. Wilkinson

257. Tecwyn Jones (ex Officer-in-charge, West African Timber Borer Research Unit), joined the Division in April this year. He is to specialize on pest problems of established forests and plantations, particularly borers of living trees, while W. Wilkinson is to concentrate on insect problems of afforestation with special attention to termites. Efforts have been made to recruit and train an adequate complement of junior staff, but at present this consists of only one graded employee and two assistants.

258. It has been necessary in the first instance to re-establish the general functions of the Division after a lapse of almost two years' inactivity. This has involved the re-equipping of the laboratories, the training of staff, and particularly the sorting of a tremendous back log of the insect collection. These measures are far from complete and will occupy the staff for a further considerable time.

259. *East African Forest Insect Survey.* The expansion of this survey, initiated several years ago by J. C. M. Gardner, is considered to be of primary importance and has been accorded full priority. The collection of insects during the past year has been carried out solely by two Tanganyika Insect Rangers, but as the present accumulation is distributed or accessed, so the volume of new collection will be increased, both by this Division and through the co-operation of the Forest Entomologists of Kenya and Uganda. The survey is conducted with object of

providing not only a complete collection of identified forest insects, but also information on the host range, seasonal fluctuations and pest potential of each species. The existing collection is good, and has permitted the Division to continue its service of distributing duplicate identified specimens to territorial departments.

260. In the past year over 1,600 named specimens have been passed to the Kenya Entomologist to form the nucleus of his territorial reference collection.

261. *Ranger Training Course.* A training course for Insect Rangers was held in August, and was attended by two Rangers from Tanganyika and four E.A.A.F.R.O. assistants. The two-week course was devoted mainly to the recognition of the major insect groups and the diagnosis of pest damage to trees, timber and lumber. Lectures on both general and specific problems were given at the meetings of the Forestry Courses here and at the Kenya Divisional Forest Officers' Conference. W. Wilkinson attended the East African Timber Advisory Board at Entebbe.

262. *General Problems and Advisory Work.* No outstanding insect epidemics have occurred in the past year, but severe defoliation of trees by a species of *Colasposoma* (Coleoptera, Chrysomelidae) is under observation at Lindi. Advice has been given to individuals, commercial firms and Government departments on the control of powder post beetles, weevils, termites and other timber pests. An investigation has been undertaken on behalf of the East African Posts and Telecommunications into insect damage to the lead sheathing of underground cables, which causes short circuiting.

ESTABLISHED FORESTS AND PLANTATIONS

T. Jones

263. Work in this field has barely started. Preliminary surveys have been conducted in the three territories and the relative priorities of the major insect problems have been assessed. From observations made, and from consultations with forestry and timber trade personnel it was apparent that this Division could best meet the immediate needs of the territories by undertaking investigations of the insect borers of living trees. A programme of work was therefore compiled which envisaged investigations of the *Oemida* and *Androeme* problems in Kenya and Tanganyika, and studies of the *Paranari* borer and ambrosia beetles in Uganda.

264. The infestation of plantations by *Oemida gahani* presents an acute problem. For several years past the Kenya Forest Entomologist has been engaged on the development of palliative control measures, such as the chemical protection of pruning scars and wounds. It has been possible to do little, however, on the basic biology of the pest, population fluctuations, the detection of the borer, evaluation of depredation, or the physiology of the insect. By mutual agreement of the Kenya and E.A.A.F.R.O. Forest Entomologists these virtually untouched aspects of the problem are to form the main lines of investigation of this Division.

265. Studies of the biology have been initiated, but severely limited by lack of essential equipment. Through the co-operation of the Chemistry Division, however, a fruitful start has been made in the investigation of the feeding habits and minimum food requirements of the immature stages. This is an essential step towards the ultimate purpose of determining the factors affecting the length of life cycle and the fecundity of *Oemida*. To facilitate examination of the larval stages, attempts have been made, with varying degrees of success, to construct composite wood breeding cells. Population assessments and studies of the seasonal fluctuations in number of adults have not been started.

266. Determination of the rhythm of activity of larval stages, based on the rate of respiration are being undertaken using the Birch-Friend Respirometer. It is hoped that present trials using acoustic recordings may prove successful and provide more precise data.

267. Considerable time has been devoted to devising methods and applying existing techniques for the detection of the borer within its host and evaluating the incidence and degree of infestation in plantations. A rapid but non-destructive method of inspection is essential for individual tree and plantation sampling, if it is desired to know the condition of the crop at any time during its thirty-odd years' rotation. Towards this end, the possibility of using ultrasonic pulse techniques and radiographic methods have been investigated. Preliminary trials have shown that ultrasonic methods can be used to detect borer holes in otherwise sound wood, but difficulties have arisen over selection of suitable probes and coupling agents. Considerable modifications of existing apparatus and experience in interpreting results are necessary before this method can be proved. Gamma-radiography and X-ray techniques also seem promising, but at

present impracticable. The use of a very small radio-active source with scintillation counter, however, seems both highly promising and economical, and this technique is being considered in conjunction with the Radiation Laboratories in the United Kingdom.

TERMITES AND AFFORESTATION

W. Wilkinson

268. The problem of the termite attack on young trees is common to all three territories, and in some areas is a serious obstacle to afforestation. With the approval of the Chief Conservators, an interterritorial investigation has been begun, to assess the situation and find the best means of control.

269. Preliminary tours have been made to see areas in which damage has been reported, during which the opportunity was taken to have discussions with forestry officers and workers. Particular note was taken of local practical difficulties in the application of suggested control measures. The main object of the survey is to collate information on the relative susceptibility of different trees to damage, the species of termite responsible, and the conditions under which attack takes place. Its concomitant function will be to allow prediction of probable termite danger in planting a new area, so enabling suitable precautions to be taken. Available data show no simple correlation of factors to explain attack, and it is clear that more evidence is needed, particularly as depredations may vary from year to year. Not infrequently termites are a secondary factor, and receive the blame for the death of trees which are unsuitable for the area, or have become moribund due to drought, disease or mechanical damage.

270. Co-ordination is planned with the Forest Entomologist of Uganda, where attack is widespread, and the problem has been accorded full priority.

271. Control measures fall into two categories—(i) Destruction of the termites and (ii) Protection of the trees by repellent barriers. Direct attack is at present impracticable against many small underground nesting species, though baiting will be attempted. Various techniques of poisoning mound-building kinds are to be tried. Protection of young trees by mixing insecticides in the planting holes is an orthodox approach, but has the disadvantage of requiring careful application, and the effect being limited to the life of the insecticide, and to its bounds of distri-

bution. In co-operation with the Kenya Forest Department, a trial has been laid down on Uuni Hill, near Machakos. This hill has a history of termite attack, and climatic conditions for trees are difficult. Five hundred *Eucalyptus paniculata* were planted in December, using five different treatments. These were: Aldrin $2\frac{1}{2}$ per cent dust, Dieldrin 2 per cent granules and Aldrin 40 per cent wettable powder in water, with both dry and wet controls. Termite attack has begun, but at this stage no comment is advisable.

272. At the request of the Kenya Forest Department, a visit was made to some upland sites between Kaptagat and Maji Mazuri. A question had been asked on the possible threat of termite attack on the extensive softwood plantations there. An assurance was given that in the conditions prevailing, the local wood-eating termites were unlikely to cause any trouble. The commonest termite is a humus-feeding *Cubitermes* which would not eat trees, though its mound might have some soil-moisture effect, and chemical difference. A simple trial was suggested to compare the growth rate of trees planted on and between mounds. If no significant difference is noted, the mounds can be ignored, and normal tree spacing employed.

HORTICULTURAL SECTION

W. B. May

FORESTRY WORK

273. All forestry nursery experiments referred to in the report of the Silviculturist were carried out by the Horticulturist.

274. Seventy-five thousand *Eucalyptus saligna* were raised for estate planting, also several thousand Pines and Cypress. Material for the planting of 50 arboretum plots was raised in the nursery.

275. Over 95 per cent success has been obtained in grafting *Pinus patula* and *Pinus radiata* with selected scion material of the same species in the field. The top cleft graft technique, using young shoot tips enclosed in a polythene bag and suitably shaded, is easy to execute, within six weeks of grafting a union is made. Both the polythene bag and shade can be removed within ten weeks of grafting.

Horticultural Work

276. The use of a polythene cover over seedbeds made reasonably airtight greatly increased the percentage of germination of several species and also saved labour, as the seedbed requires no attention until germination is complete. In dry areas this has proved extremely useful.

277. A propagating frame covered with polythene sheeting, insulated by a second layer of polythene on the inside, has proved highly successful for the rootings of cuttings of numerous species.

278. A considerable amount of grafting work on coffee seedlings has been carried out for the virologist. A grafting technique similar to that used with Pines gave 95 per cent successful unions, both under glass and in the field.

279. Thirty-nine varieties of *Melinis minutiflora* (molasses grass) were raised for the Systematic Botanist.

280. Floral decorations were provided for the East Africa High Commission stand at the Nairobi Royal Agricultural Society's show. The horticultural section represented E.A.A.F.R.O. at this year's Royal Agricultural Show, the main theme of the exhibit being plant propagation, latest nursery techniques and the use of fertilizers in the nursery. The stand was well attended, much interest being shown in the model seedbed and plant propagating frame.

281. The Horticulturist continued to do advisory work on nursery techniques and the growing of plants generally for the three E.A. Departments of Forestry.

THE EAST AFRICAN HERBARIUM

B. Verdcourt, G. L. Lucas (at Kew), D. M. Napper, J. G. Newbould, R. Polhill and G. R. Williams

282. Dr. Verdcourt was on home leave from January until the end of July, during which time he spent over two months working at the Royal Botanic Gardens, Kew, the British Museum (Nat. Hist.) and also paid visits to Paris and Berlin. He also visited the National Herbarium in Pretoria during his journey from Cape Town to Nairobi by car. Mr. Newbould continued working as a temporary botanist until August and Mr. R. Polhill joined as a temporary botanist on 1st November. Miss Napper was in charge of the herbarium during the absence of Dr. Verdcourt. Mr. G. L. Lucas joined the staff as Botanist on 5th October and started a year's work at Kew where he will gain experience of East African plants before taking up his duties in the East African Herbarium.

283. Two hundred and seventy-eight accessions have been received during the year, totalling 11,400 specimens for determination, 2,245 named duplicates and 479 specimens received on loan for study or naming, Routine naming of collections and the supplying of information takes up an ever increasing amount of the staff's time and it is unlikely that without a change in the function of the herbarium that any research will ever be done. Even increases in staff do not seem to help improve facilities for research, since so many routine tasks need doing that increases are swallowed up doing tasks which have been shelved for several years. 9,430 specimens have been determined; a considerable proportion of these have been brought in by visitors in person. This involves rapid naming and is not to be encouraged since naming is best done carefully. Material is preferably sent in by post, save of course in the case of urgent police and medicinal cases.

284. As usual a large number of queries concerning poisonous and medicinal plants have been dealt with and an increasing number of people are using the records contained in our card indices and files. This information is a necessary preliminary to the screening of our flora for drugs and other interesting compounds. 12,121 specimens have been sent to other institutions, including named duplicates and specimens sent on loan for study.

285. Laying away of named mounted sheets is still a major problem. It is not a task capable of being handled by untrained persons since they do not spot such errors as wrong labels, archaic nomenclature, etc. Considerable headway has been made with the

21,500 which were mentioned last year but a further 5,000 have been added and another 3,500 named mounted sheets need sorting. The total additions to the herbarium over the period 1958/59 will therefore be about 30,000 sheets which rivals the number which large European herbaria have to deal with. Count has been lost of the total number of sheets in the Herbarium but it is about 150,000 sheets. The actual number is of no importance and indeed, could only be assessed accurately by an actual count. The upper floor of the Herbarium is now completely furnished and Miss Napper has arranged the Monocotyledons and lower plants there, the lower floor being entirely devoted to Dicotyledons.

286. Research has been very limited. Miss Napper has continued her studies on East African Grasses and Dr. Verdcourt sent off a revised account of the Convolvulaceae for what is hoped will be the final time. The plates for this work are still not completed.

287. There have been many visitors during the year, a few of whom have worked in the Herbarium for extended periods. Miss Coetzee of the University of the Orange Free State, Bloemfontein (Department of Palynological Research) collected pollen off several hundred plants in the Herbarium; Dr. Zinderen Bakker of the of the same institution also paid a visit later in the year. Professor Heady and Dr. Moomaw worked out or helped the Herbarium staff to work out large collections they had made in connexion with ecological surveys. Several distinguished visitors have used the Herbarium facilities including Dr. George Taylor, Director of the Royal Botanic Gardens, Kew; Dr. H. F. Mooney, Colonel R. Meinertzhagen and Dr. Guido Moggi.

288. As usual numerous new taxa have been described during the year from specimens originating from the East African Herbarium and yet further types have been found. The total number is now 1,055. The most interesting botanical find during the year is the discovery by Mr. Terence Adamson of the fern *Adiantum reniforme* L. on both Mount Kulal and Marsabit. This is the first really authentic record for the African continent.

289. Field work has again been on a limited scale. Miss Napper visited the coast south of Mombasa, but her duties as Acting Botanist in Charge precluded field work during the earlier part of the year. Dr. Verdcourt also visited the coast to obtain specimens of a rare *Bauhinia* from Mrima Hill and also made general collections in the Machakos District. In October Dr.

Verdcourt accompanied Dr. Taylor on a short trip to Kitale and a few specimens were collected on Mount Elgon and in the Cherangani Hills in company with Colonel T. H. E. Jackson. Mr. Newbould returned from his Mathews Range *safari* in January and later visited W. Kilimanjaro and other nearby localities. He joined the Second Oxford University Expedition to Mount Kungwe and after leaving E.A.A.F.R.O. spent his final leave in the Ruwenzori Mountains. His collections have not been worked out but run into several thousand numbers including a large number of mosses. This material has been taken to England when named sets will be sent to the East African Herbarium.

MISCELLANEOUS SCIENTIFIC SERVICES

JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY

L. D. Verdcourt, J. U. Ferris, F. M. Searle and D. N. Lazarus

290. The Librarian was on U.K. leave for the first seven months of the year under review, and Mrs. J. U. Ferris was in charge of the Joint Library. During this time the routine work was kept up to date and several long-term tasks were started, including an index of microfilm and photostat copies which have been received in the last few years. A further index was made of the bulletins of the Ministry of Agriculture so that it is now easier to trace a bulletin by its subject. Mrs. Ferris also did a good job on the large pile of unsorted reports received by E.A.V.R.O. and a Roneodex index was compiled for future records. The reports themselves have been filed in geographical order on the shelves.

291. The microfiche reader arrived just before the end of the year and was established in a study carol at the end of the library. Mrs. Ferris reported that the machine was used only a limited amount during the first half of the year and this was found to be so from August-December, 1959. However, it is felt that although the machine is not used constantly, it will be of value over the next few years as more and more articles are being obtained on microfilm.

292. The first East African Library Association Conference was held in the Conference Room at E.A.A.F.R.O., and was well attended by Librarians from all over East Africa. The new microfiche reader was demonstrated and a bookbinding exhibition was displayed. Sir Bruce Hutt gave his presidential address and Mr. John Brown, publisher to the University of Oxford also gave a short address. This type of conference always proves to be of latent value through personal contact with other Librarians and as an aid to future co-operation between libraries in East Africa.

293. The Contoura copying machine which was ordered early in the year arrived from England and was set up and used for the Joint Library. There has long been a need for such a machine to copy articles from valuable books for bench use, and to save postage when publications are sent on loan. The only snags in using this machine would appear to be the price of the special type of paper and the fact that the developer quickly deteriorates. However these are difficulties which it is hoped to surmount in the coming months.

294. During the latter half of the year no assistance was available in the library and consequently routine work only was maintained, but Mrs. Searle has started part-time work in December and already several major jobs are being planned. These include a stock check and adequate signposting in the main library, as well as certain rearrangements in classification which are long overdue.

295. The bookbinding staff continued to work very well and the scheme for binding books from other organizations ran smoothly, 338 books being bound as well as making 248 pamphlet boxes. The binding of E.A.A.F.R.O./E.A.V.R.O. books is kept well up to date.

296. On the whole the work in the Library progresses satisfactorily but it is still hampered by lack of funds for the purchase of more modern text books. Obtaining microfilm and photostat copies quickly from South Africa and England is also a great problem and at present largely dependent on personal contacts made by the Librarian whilst on long leave in both those countries. The Commonwealth Bureaux have proved very helpful during the last few years in tracing references and having microfilms made. Various private firms undertake such work but this is an expensive and lengthy method and they cannot always get access to the important reference libraries such as the Science Museum.

EAST AFRICAN AGRICULTURAL JOURNAL

J. Glover

297. It is with regret that we record the departure of Dr. Duthie, on the occasion of his retirement from the service and from the editorship of this Journal.

298. Dr. Duthie became Assistant Editor in April, 1945, and took over the full work of Editor in 1947, a duty which he has performed continuously since then, except for the periods of his overseas leave. During these 14 years, Dr. Duthie has more than maintained the high standard of the presentation of papers on scientific agriculture which the Journal has enjoyed from its inception.

299. The Journal has now been published for 25 years and its scope has been widened with time. It now includes more papers dealing with the physical and chemical as well as the biological sciences for each is linked with agriculture in the widest sense. In

consequence, it is more nearly a record of much general research in East Africa, than strictly an agricultural journal. As a result, the East African Agricultural and Fisheries Research Council, with the approval of the three East African Governments, have decided that the title should be changed to the East African Agricultural and Forestry Journal in 1960, to indicate in part the wider scope of the contents. The change will take place with the July, 1960, number, which is the first of the new volume, the twenty-sixth.

300. The increase in price of the Journal has involved a net loss of some 150 subscribers. This is some 50 less than when the subscription was earlier raised from five to ten shillings. A further increase in postal charges has also dealt a blow to our economy.

301. Mrs. P. D. Hosegood, the Assistant Editor, was on leave during much of the year and her place was taken by Mrs. G. Chamberlain. Both continue to give devoted service to the prosaic details without which publication would be erratic or impossible.

EAST AFRICAN PLANT QUARANTINE STATION

F. M. L. Sheffield and P. J. Dickinson

302. There has been no change in the staff during the year under review. The scientific supervision given to the station by E.A.A.F.R.O. has already been mentioned (p. 55).

303. The glass-houses conform to the requirements agreed by the Inter-African Phytosanitary Commission in 1958 but it has been necessary to alter the ancillary buildings to conform to the minimum required standards. This has been done by the erection of a small extension for sterilization and potting and reorganization of the previously existing building to include a small chamber for inspection of plants on arrival, more adequate storage space and general improvement of the internal structure to allow a higher standard of cleanliness.

Species Held or Received During 1959

304. *Banana.* It has been found necessary to destroy all stools of the three varieties, Giant Cavendish, Gros Michel and Lacatan, introduced late in 1958 because they were found to be infected with fungal disease and with nematodes.

305. *Beans.* Seed of three varieties of Haricot beans was imported by the Department of Agriculture, Tanganyika Territory. As it was impossible to obtain from source a certificate of freedom

from Bacterial wilt (*Corynebacterium flaccumfaciens*) they are being grown in quarantine. If the plants are found to be healthy they will be kept to maturity and the resultant seed will be released.

306. *Chrysanthemum.* Of 26 varieties previously imported, only six remained in January, 1959, all plants of all others having either shown symptoms of virus infection or having been found to be symptomless carriers when tested by mechanical inoculation to indicator plants. The remaining plants were shown to be symptomless carriers when scions were grafted to the indicator, *Chrysanthemum* var. Mistletoe. They were consequently destroyed. The importation of ornamental Chrysanthemums is now completely prohibited even through quarantine.

307. *Coffee.* (1) *Coffea arabica.* Varieties Cos 34/1; 87/1; 110/2; 113/1; 134/4 were received from the Centre de Investigucao das Ferrugens do Cafeiro, Oeiras, Portugal, and have been released to the Jacaranda Coffee Research Station, Kenya.

(2) A further consignment of varieties Cos 110/2, 113/1, 134/4 has been received for the Coffee Research Station, Lyamungu, Tanganyika Territory, and are now ready for release.

(3) *Coffea Excelsa.* Varieties 121/3; 490/51; Dybouwskii and Zaailinge java received from Laboratorium Tropische, Landbouwplantenteelt Ritzema, Bosweg, Holland, on behalf of Jacaranda Coffee Research Station, are still held in quarantine. Five very small seedlings also included in the consignment did not survive.

308. *Guatamala Grass.* (*Trypsacum laxum*). A consignment of plants sent from West African Maize Research Unit, Moor Plantation, Ibadan, for use in research at E.A.A.F.R.O. were delayed three months in transit and were dead on arrival.

309. *Pineapple.* A single top of the Azores pineapple St. Michael was successfully grown. Tests to indicator plants showed it to be free from Tomato Spotted Wilt Virus. It was released to the Horticultural Section of the Department of Agriculture, Kenya.

310. *Pelargonium.* (1) Kenya Department of Agriculture imported some cuttings of a high oil strain Pelargonium from Réunion. They were dead when received.

(2) A further consignment of cuttings was received on behalf of a grower but owing to heating in transit, these did not survive.

(3) Cuttings of a second importation made by the same grower are now well established. Tests to standard indicator plants have shown them to be free from Tomato Spotted Wilt Virus: it now remains to test them for the presence of latent viruses by grafting to Pelargonium seedlings.

311. *Sugar Cane.* As in the past the largest amount of material handled has been sugar cane. During 1959, the following varieties were released to open quarantine at the Kawanda Research Station, Uganda:—

B.3337, 42231, 45151, 47419, 49119.
B.O.3, 14.
Co. 349, 449, 476, 718, 740, 746, 765, 798, 911, 1001.
Co.S.443, 510.
C.P.29/116, 44/101.
D.109.
Ebène 1/37.
H.37/1933.
M.31/45, 147/44.
N.10, 50/93, 50/123, 50/211.
P.O.J.2940.

The following varieties imported during 1958 are still held in closed quarantine at Muguga:—

Co.991, Q.67, Q.70, Trojan.

Through the generosity of the Directors of the Sugar Breeding Institute, Coimbatore, India, the Experiment Station of the S.A. Sugar Association in Natal and the U.S. Department of Agriculture, the Director of E.A.A.F.R.O. was able to import the following varieties during 1959:—

B.4744.
B.O.10, 11 (twice).
C1. 41/223, 47/83, 47/143.
Co.440, 680, 684, 785.
C.P.31/511, 48/103, 50/28, 52/68, 52/107, 53/18.
M.134/32.
P.O.J.3067.
P.R.809, 980.
Ragnar.

We were obliged to destroy Co.785 as about six months after arrival both stools developed conspicuous symptoms of unknown origin. Other varieties B.O.10, Co.670, Co.684 which came in the same consignment and were held in the same glass-house, were

apparently healthy. Setts were taken from them, given the longest period of hot-water treatment they would survive and were then requarantined.

We also destroyed C.P.52/110 which was found to be infected with mosaic disease virus. Setts of the first importation of B.O.11 failed to germinate and were then found to have a stem-rot. The variety was reimported.

The collection of varieties held at Muguga now contains two stools of each of 77 varieties. The existing enclosure is now filled and more land has been made available by the Director of E.A.A.F.R.O. for extension of the collection.

Setts of the following varieties, taken either from our collection or when the varieties passed from closed to open quarantine, have been sent abroad during 1959:—

To Nyasaland—Co.475, 513, 602, 617, 622, 678, Q.50.

To South Africa—B.O.14, Co.718, 740, 746, 765, 798, 911, 1001.

Co.S.443, 510.

To Sudan—P.O.J.3016, P.R.1000, Q.56.

Inter-African Phytosanitary Commission

312. Mr. Dickinson continued to act as Secretary to the Standing Technical Committee on Plant Import and Export which has entailed a considerable amount of work.

313. A complete new Schedule of Plants was issued during the year, but following the I.A.P.S.C. meeting in London in October a certain amount of revision will still be necessary to conform with the recommendations of this meeting.

Visitors

314. The East African Quarantine Station received a number of visits during the year from members of Kenya and Uganda Legislative Councils.

315. Dr. Taylor, Director of Royal Botanical Gardens, Kew, England, also made a visit to the station during his stay in Kenya.

316. Mr. Ting Wen Poh from Malaya arrived in December for a six-week stay to study quarantine methods and legislation governing the application of Plant Import Control.

LIST OF PUBLISHED PAPERS BY E.A.A.F.R.O. STAFF DURING THE YEAR 1959

BIRCH, H. F. (1958). Further aspects of humus decomposition. *Nature, Lond., 182,* 1172.

BIRCH, H. F. (1958). The relationship between the digestibility and decomposibility of some animal feeds. *J. agric. Sci., 51,* 377–379.

BIRCH, H. F. (1959). Further observations on humus decomposition and nitrification. *Plant and Soil, 11,* 262–286.

BIRCH, H. F. (1959). Simultaneous decomposition processes in soils. *Nature, Lond., 183,* 1415.

BOCK, K. R., ROBINSON, J. B. D., and CHAMBERLAIN, G. T. (1958). Zinc deficiency induced by mercury in *Coffea arabica. Nature, Lond., 182,* 1607-1608.

CHAMBERLAIN, G. T. (1959). Trace elements in some East African soils and plants. I. Cobalt, beryllium, lead, nickel and zinc. *E. Afr. agric. J., 25,* 121–125.

FRIEND, M. T. (1959). Shade measurement by a chemical radiation meter. *E. Afr. agric. J., 25,* 110–112.

GLOVER, J., and DUTHIE, D. W. (1958). The apparent digestibility of crude protein by non-ruminants and ruminants. *J. agric. Sci., 51,* 289–293.

GRIFFITH, A. L. (1958). A list of *Eucalyptus* species known to be attacked by the snout beetle *Gonipterus scutellatus* (Curculionidae). *E.A.A.F.R.O. For. Tech. Note No. 9* and *Emp. For. Rev., 38,* 200–201.

GRIFFITH, A. L. (1958). The stock mapping to quality classes of an even aged forest. *E.A.A.F.R.O. For. Tech. Note No. 10* and *Emp. For. Rev., 38,* 301–303.

GRIFFITH, A. L. (1959). Forestry courses in East Africa. *Emp. For. Rev., 38,* 7–8.

GRIFFITH, A. L. (1959). The Second Inter-African Forestry Conference, Pointe Noire. *Emp. For. Rev., 38,* 139–140.

LAMPKIN, G. H., QUARTERMAN, J., and KIDNER, M. (1958). Observations on the grazing habits of grade and Zebu steers in a high altitude temperate climate. *J. agric. Sci., 50,* 211–218.

LEDGER, H. P. (1959). How to decide live weight of steers: the economy of producing heavy versus light beef carcasses under existing K.M.C. regulations. *E. Afr. Field and Farm, 24,* (256) 19–21.

LEDGER, H. P. (1959). A possible explanation for part of the difference in heat tolerance exhibited by *Bos taurus* and *Bos indicus* beef cattle. *Nature, Lond., 184,* 1405–1406.

MAY, W. B. (1959). In your garden. *E. Afr. Field and Farm, 24,* April–December.

MCCULLOCH, J. S. G. (1959). Soil temperatures near Nairobi, 1954–1955. *Quart. J. roy. met. Soc., 85,* 51–56.

MILLBANK, J. W. (1959). The physiology of nitrification in Kenya highland soil. *Plant and Soil, 11,* 293–311.

PAYNE, W. J. A. (1959). A possible vitamin E deficiency occurring in a herd of pigs fed standard rations in the tropics. *Nature, Lond., 183,* 828–829.

PAYNE, W. J. A. (1959). Identical cattle twins for animal husbandry experimental work in East Africa. *E. Afr. Field and Farm, 24,* 18.

PEREIRA, H. C. (1959). Lessons gained from grazing trials at Makavete, Kenya. *E. Afr. agric. J., 25,* 59–62.

PEREIRA, H. C. (1959). Physical basis for land use policy in tropical catchment areas. *Nature, Lond., 184,* 1768–1771.

PEREIRA, H. C. (1959). Practical field instruments for estimation of radiation and of evaporation. *Quart. J. roy. met. Soc., 85,* 253–261.

PEREIRA, H. C. (1959). Tea gardens or tall forests? *Corona, 11,* 209–213.

SHEFFIELD, F. M. L. (1959). Stem-pitting condition in coffee. *Kenya Coffee*, July.

SHEFFIELD, F. M. L. (1959). Sugar cane importation. *E. Afr. agric. J., 25*, 16–17.

STOREY, H. H., and HOWLAND, A. K. (1959). Resistance in maize to the tropical American rust fungus, *Puccinia polysora*. Part 2. Linkage of genes Rpp_1 and Rpp_2. *Heredity, 13*, 61–65.

TRAPNELL, C. G. (1959). Ecological results of woodland burning experiments in Northern Rhodesia. *J. Ecol., 47*, 129-168.

VERDCOURT, B. (1959). The cowries of the East African coasts. *J. E. Afr. nat. Hist. Soc., 23*, 130–134.

VERDCOURT, B. (1959). *Moringa*—a correction. *Kew Bull., 1958*, 384–386.

VERDCOURT, B. (1959). Scorpion shells. *J. E. Afr. nat. Hist. Soc., 23*, 146.

WHITEHEAD, A. G. (1958). *Rotylenchoides brevis* n.g., n.sp. (Rotylenchoidinae n.subfam.: Tylenchida). *Nematologica, 3*, 327–331.

WHITEHEAD, A. G. (1959). *Hoplolaimus angustalatus* n.sp. (Hoplolaiminae: Tylenchida). *Nematologica, 3*, 99–105.

WHITEHEAD, A. G. (1959). *Nothanguina cecidoplastes* n.comb. (syn. *Anguina cecidoplastes* (Goodey, 1934) (Filipjev, 1936) Nothotylenchinae: Tylenchida). *Nematologica, 3*, 70–75

WHITEHEAD, A. G. (1959). *Scutellonema clathricaudatum* n.sp. (Hoplolaiminae: Tylenchida), a suspected ectoparasite of the roots of the cotton plant (*Gossypium hirsutum* L. var. U.K.51). *Nematologica, 4*, 56–59.

WHITEHEAD, A. G. (1959). *Trichotylenchus falciformis* n.g., n.sp. (Belonolaiminae n. subfam. Tylenchida Thorne, 1949), an associate of grass roots (*Hyparrhenia* sp.) in Southern Tanganyika. *Nematologica, 4*, 279–285.

WHITEHEAD, A. G. (1959). The root-knot nematodes of East Africa. I. *Meloidogyne africana* n.sp., a parasite of arabica coffee (*Coffea arabica* L.). *Nematologica, 4*, 272–278.

WHITEHEAD, A. G. (1959). *Hoplolaimus aberrans* n.sp. (Hoplolaiminae: Tylenchida). *Nematologica, 4*, 268–271.

WILKINSON, W. (1958). Two new species of *Kalotermes* Hagen from West Africa (Isoptera: Kalotermitidae). *Proc. roy. ent. Soc., Lond., B, 27*, 109-115.

WILKINSON, W. (1959). Four new species of Kalotermitidae from East Africa (Isoptera). *Proc. roy. ent. Soc., Lond., B., 28*, 61–72.

G.P.K. 4454—2,000—3/60